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CONTRIBUTIONS TO BOTANY, 1959

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FOREST AND PEATLAND AT HAWLEY LAKE, NORTHERN ONTARIO

By HUGO SJÖRS¹

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Accompanied by his wife as assistant, the author took part in botanical exploration in the Hudson Bay lowland in 1957 under the auspices of the National Museum of Canada, Ottawa, under the stimulating leadership of Dr. A. E. Porsild, Chief Botanist, who has also determined or checked all collected vascular plants and revised the manuscript. Mr. W. K. W. Baldwin, Assistant Botanist of the National Museum, was a most helpful member of the party. Dr. H. Persson, Riksmuseum, Stockholm, has determined or checked the bryophytes. The lichens were determined by Dr. S. Ahlner and Dr. T. Hasselrot, and the charophytes by the late Dr. H. Horn af Rantzien, all from the same museum. Two hepatics were determined by Dr. S. Arnell, Gävle, Sweden.

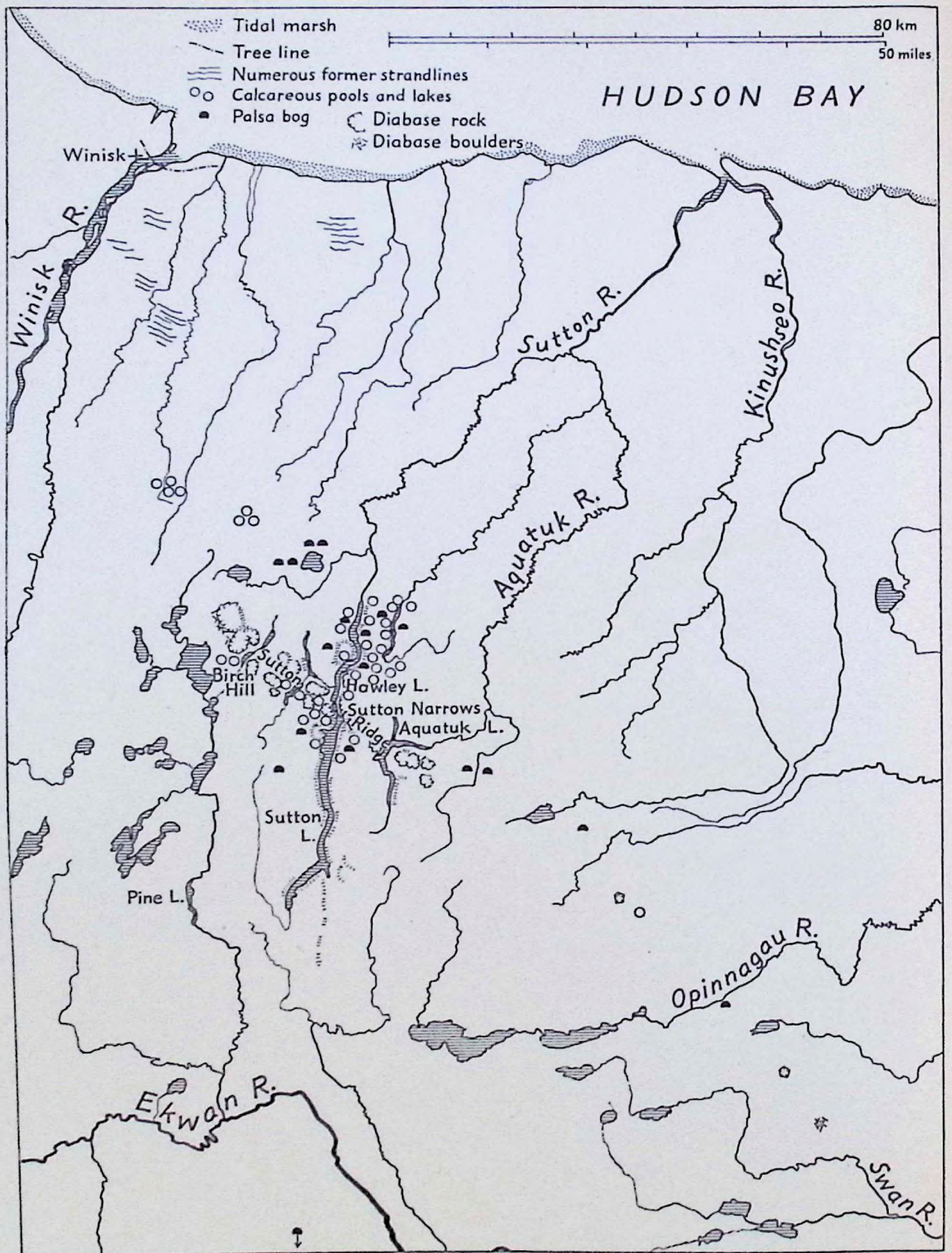
Equipment and reimbursement of expenses for the field party were supplied by the National Museum of Canada. Air transportation in the field was most kindly furnished by the Ontario Department of Lands and Forests. We owe special thanks to the friendly aviators, the pilot Mr. Tommy Cooke and Mr. George Wood. A generous grant from the Banting Fund through the Arctic Institute of North America made our participation possible.

To all these persons and institutions the author wishes to express his sincere gratitude.

THE DISTRICT INVESTIGATED

The northernmost part of Ontario belongs to the Hudson Bay lowland, formed by almost horizontal, chiefly Palæozoic bedrock covered by clayey till and glacial or post-glacial calcareous marine clays. Following post-glacial emergence of the land, different types of peatland landscapes developed (Coombs, 1954; Moir, 1954; Hustich, 1957; Sjörs, 1959).

¹Royal School of Forestry, Stockholm 51, Sweden.



TEXT FIGURE 1. Situation of the area of investigation.

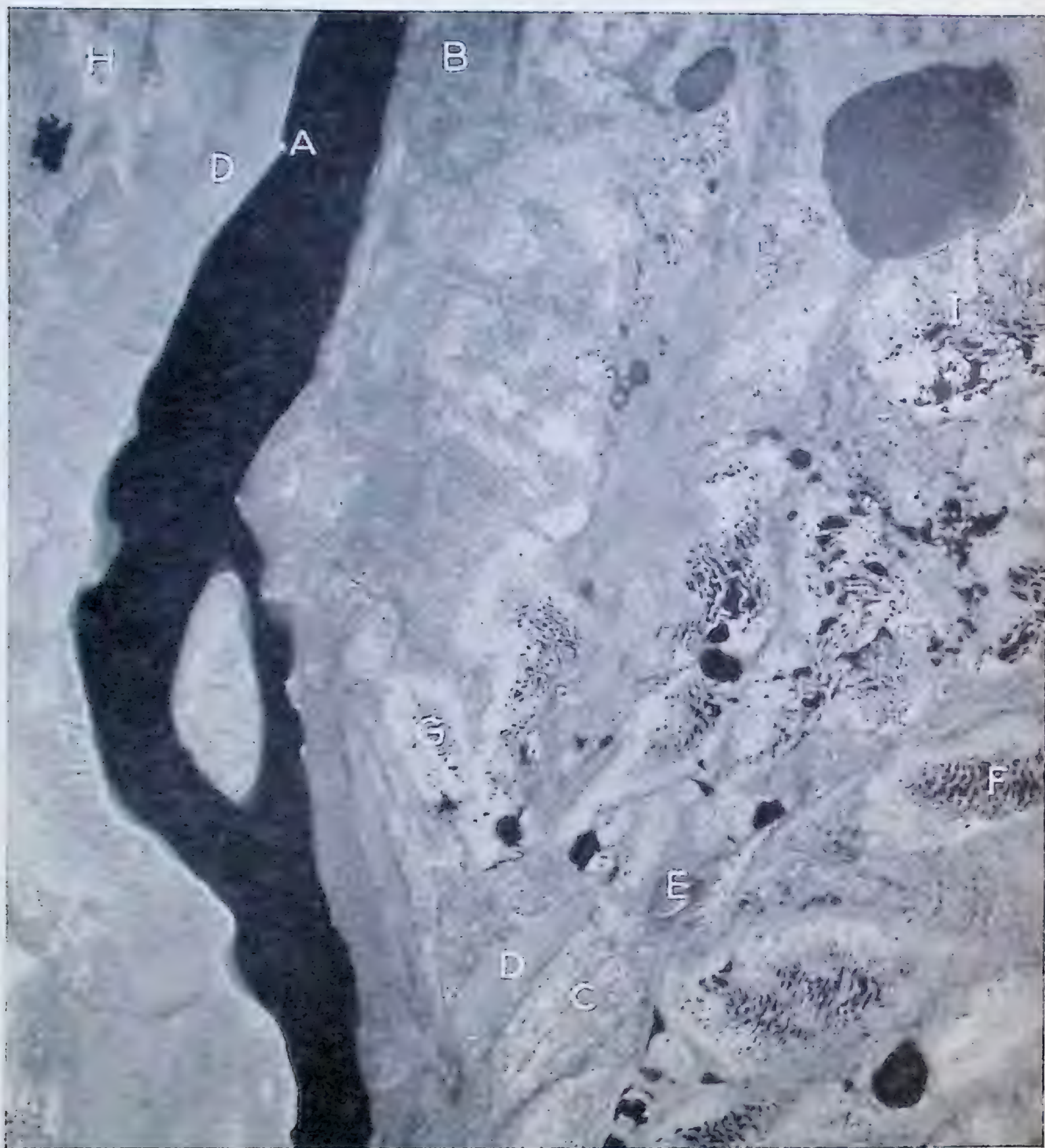
The lack of relief in the lowland is broken only by a row of low diabase hills trending northwest to southeast, from 50 miles south to about 75 miles south-southeast of Winisk. Small outcrops, almost certainly of diabase, were noted from the air farther southeast at about $54^{\circ} 8' \text{ N.}$, 84° W. , and a single small outcrop as far southeast as $53^{\circ} 52' \text{ N.}$, $83^{\circ} 35' \text{ W.}$; beyond this a single boulder field was observed in approximately $53^{\circ} 47' \text{ N.}$, $83^{\circ} 28' \text{ W.}$ The diabase formation may be related to igneous rock exposed on islands and on the eastern shore of Hudson Bay.

The diabase hills form an irregular escarpment along their southwestern edge but dip gently toward northeast where they disappear under the quaternary deposits. The diabase rests on a slate of high iron content, and this again, in part, rests on dolomite which is exposed only rarely but may be the source of much of the glacial till. All these rocks dip gently toward northeast or north, although at a considerably steeper angle than does the general slope of the country. The geology was admirably described by Hawley (1925).

There are a few deep fissure-valleys almost at right angles to the diabase ridge, i.e. trending chiefly south to north. The longest of them is occupied by Sutton Lake south of the diabase ridge, and by Hawley Lake north of it. Water from the former spills into the latter through Sutton Narrows. The steep valley-slopes along the two lakes have better drainage than the surrounding country and are well forested, except where recent fires have destroyed the forest.

The vegetation on the diabase rock itself is more or less silicicolous. Mineral soil elsewhere in the area is generally strongly calcareous except for some local sand-beds, and the upper horizons of podsolized soils. The C horizon of these podsoles frequently consists of a kind of marl which contains abundant fragments of marine shells and is strongly effervescent with hydrochloric acid. Acid peat deposits occur in numerous places. However, all soils, including peats, reached by such ground water that has percolated through mineral soil, are highly calcareous. This is also evident from the vegetation of damp areas in the forest, where calcicolous plants occur between acid moss cushions. Where moving ground water comes to the surface, calcium carbonate is even precipitated and deposited together with peaty matter in small depressions.

Above the valley-slopes the adjacent plateau carries numerous areas of shallow peatland, which also is largely calcareous. These peatlands, which are fens in the sense used in Europe, in this district have no typical strings (or hummocky ribbons) but are frequently spotted by wet patches (*flarks* or *rimpis*). The flarks carry little or no vegetation except for micro algae, and in the district around Hawley Lake may frequently be distinguished by their light-coloured bottom material. Light-coloured, calcareous bottom deposits were noted also in many of the shallow pools of the plateau and in the shallow parts of the otherwise deep and clear fissure-lakes. They are very conspicuous from the air and are easily picked out on aerial photographs. Some of the finest examples were noted in a series of small, oblong, and rather shallow lakes east and west of the Sutton Narrows, but, generally speaking, calcareous lake-bottom deposits are common in lakes and ponds along and to the northwest of the entire Sutton Ridge. An isolated example was seen about 30 miles to the southeast (See Text Fig. 1).



Northern section of Hawley Lake. About three miles of the lake shown in vertical view. *A*—Ontario Dept. of Lands and Forest cabin. *B*—Dense black spruce forest. *C*—Open lichen - black spruce woodland on gravel ridges. *D*—Burnt forest. *E*—Small tarns with white calcareous bottoms. *F*—Patterned fen with “flarks” (darkish in this case). *G*—The eastern bog visited, with small palsas. *H*—The western palsa bog, studied more in detail. *I*—Probably the best developed palsa bog, also with large bog-pools. (Enlarged section from R.C.A.F. photo A. 14201-14.)

As expected, water from Hawley Lake had a high content of Ca^{2+} ions (Table 1). The pH value was 7.9. The transparency of the lake was about 6 m, and the colour of the water (in late June) greyish green. The following aquatic plants were recorded: *Eleocharis acicularis*, *Hippuris vulgaris*, *Potamogeton Friesii*, *P. filiformis*, *P. gramineus*, *P. Richardsonii*, *P. vaginatus*, *Ranunculus trichophyllus* var. *eradicatus*, *Myriophyllum exalbescens*, *Chara globularis* Thuillier (= *fragilis*), *Ch. contraria*. In the latter part of June, 1957, when the temperature of the water was still low, the seasonal growth of the aquatic plants had just commenced. Lake trout as well as speckled trout are abundant in Hawley Lake.

Marine shells derived from clay deposits are abundant along the lake shore. Common plants along the lake shores are *Eleocharis acicularis*, *Caltha palustris*, *Primula mistassinica*, *Rubus acaulis*, *Salix vestita*, *Anemone parviflora*, *Erigeron hyssopifolius*, *Selaginella selaginoides*, *Equisetum scirpoides*, *Carex capillaris*, *C. gynocrates*, *C. scirpoidea*, *C. vaginata* etc. In sites with some seepage, *Hippuris vulgaris* and the large moss *Fontinalis novae-angliae* grow above water. In one place along the southeast shore *Rhododendron lapponicum* was seen, and on the northeast shore *Bartsia alpina* and *Arabis alpina* occur, the latter growing on calcareous sand. A complete list of the vascular plants collected or noted by the party will be published by A. E. Porsild. A list of the bryophytes has been prepared by Persson & Sjörs (1960).

TABLE 1. CHEMICAL PROPERTIES OF A WATER
SAMPLE FROM HAWLEY LAKE.

(Analysis by Dept. of Mines and Technical Surveys, Mines Branch, Industrial Waters Section, Ottawa). Date of sampling July 5, 1957.

	Ions, in parts per million:			
	Ca^{2+}		CO_3^{2-}	
Temperature.....7°C	32.1		0	
Transparency.....ca 6 m	Mg^{2+}	6.8	HCO_3^-	131
pH immediately.....7.9	Na^+	5.3	SO_4^{2-}	4.5
pH after 32 days' storage.....8.0	K^+	0.6	Cl^-	5.9
Conductivity $\times 10^6$, 20°C, do.....207	Total Fe	0.02		

Manganese, nitrate, phosphate, silica: beyond sensitivity of analysis.

FOREST VEGETATION

In this part of the Hudson Bay lowland the tree-line everywhere is close to or only a few miles from the coast, and only along the coast south of Cape Henrietta Maria a belt of treeless tundra attains a width of from

8 to 10 miles. The vegetation of this coastal tundra is not truly arctic and may be termed hemi-arctic (Rousseau 1952). Farther southwest the subarctic woodlands begin. On the few well-drained sites the trees gradually increase in height. They seem to reach their normal dimensions already beyond the middle Ekwan River where the forest is definitely boreal rather than subarctic. The subarctic belt is thus exceptionally narrow, rarely exceeding 100 miles in width. This, no doubt, results from a rapid increase in summer temperature as we move from the coast toward the interior. Hawley Lake, from 44 to 56 miles from the coast, has a central position in the subarctic belt.

Black spruce (*Picea mariana*) is the dominant tree throughout the area, on dry or wet, drained or undrained soils. White spruce (*P. glauca*) is found along the lake shores and in a few other places with rich, moist, but well-drained soil. Aspen (*Populus tremuloides*) is less common; it is found in similar places as the white spruce but chiefly on sloping ground near the south end of the lake. Balsam poplar (*P. balsamifera*) grows scattered in the forests, and young individuals occur here and there on the burnt areas. Tamarack (*Larix laricina*), which rarely reaches tree size, is mainly confined to wet sites and to peatland. No other species of trees are known to occur at Hawley Lake. Below the south-facing diabase bluffs of Sutton Ridge, the forest vegetation is richer, although most

PLATE II



Lichen -- black spruce woodland between Sutton Lake and Winisk.

species are shrubby. In Hawley's map one of the westernmost diabase outcrops is called Birch Hill, suggesting that paper birch (*Betula papyrifera*) was noted there. In National Topographical map sheet 43 N.W. 1, a lake southwest of Hawley Lake is named Pine Lake. This may indicate that a stand of jack pine (*Pinus Banksiana*) occurs there. Otherwise the nearest pine stands are on the Ekwan River (See maps in Hustich (1957) for distribution ranges of the trees).

Among the more conspicuous shrubs of the Hawley Lake area may be mentioned willows (notably *Salix Bebbiana* and *S. glauca*), junipers (*Juniperus communis* var. *depressa* and *J. horizontalis*), *Potentilla fruticosa*, *Amelanchier Bartramiana*, *Lonicera involucrata*, *L. villosa*, *Ribes glandulosum*, *R. triste*, *R. hudsonianum*, *R. oxycanthoides*, *Rosa acicularis*, *Shepherdia canadensis*, *Viburnum edule*, *Rhamnus alnifolia*, *Alnus crispa*, *Betula glandulosa*, *Ledum groenlandicum*, and *Chamaedaphne calyculata*.

The black spruce forest on well-drained soil barely reaches pulpwood size and rarely exceeds about 35 feet in height. There are, however, a few sites where the forest is slightly taller, and many large and poorly drained areas where it is lower.

More or less mature, unburnt black spruce forest varies from almost pure lichen type on dry soil, or moss-lichen types rich in dwarf-shrubs on normal drained soil, to various types of "muskeg" or swamp forest. There is no trend toward a common monoclimate in the different successions present in the forest vegetation. Factors of relief lead to different drainage and leaching processes, and to the formation of widely different kinds of humus cover, viz. *mor* (i.e. raw humus) or peat. However on the forested sites, notably the drier ones, succession is interrupted at intervals by fire. The percentage of burnt-over land is very high, and in some cases the fires are ascribed to man. Large fires destroyed much of the forest along the west shore of Hawley Lake in 1948. Regeneration is remarkably poor on the burns, although cones are abundant on the short, crowded upper twigs of the black spruce.

Open lichen spruce woodland is not uncommon here but was only seen from the air. The best examples are found on eskers and gravel ridges east of Hawley Lake. The spruce trees are widely spaced, and the ground cover appears to be a carpet of pure lichen, with little or no growth of vascular plants. This kind of forest has been mentioned by Hustich (1957, p. 34) from elsewhere in the lowland and from Labrador (1951). In the Old World, the spruces are replaced by pine in corresponding types of woodland. In northernmost subcontinental Sweden and Finland, more or less scrubby birch (*Betula pubescens* ssp. "*tortuosa*") replaces pine in the lichen woodland on plateaux above the limit of *Pinus silvestris*.

In most of the mature forest on well-drained soil, mosses and lichens, mixed in varying proportions, grow below a well-developed story of low shrubs and dwarf-shrubs. A few sample plots are recorded in Table 2, including one from a seasonally wet forest area (No. 4), and one from an area of forest burnt nine years ago (No. 5).

TABLE 2. SAMPLE PLOTS (ABOUT 100 m²) IN SPRUCE FOREST AT HAWLEY LAKE

	1	2	3	4	5
TREE LAYER					
<i>Picea glauca</i> : Cover.....		60 %			
Maximal height.....		14 m			
Maximal diam. (br.h.).....		30 cm			
<i>Picea mariana</i> : Cover.....	60 %	30 %	60 %	20 %	dead
Average height.....	9 m		10 m	8 m	
Maximal height.....	11 m	10 m	14 m	11 m	10 m
Maximal diam. (br.h.).....	12 cm	15 cm	15 cm	18 cm	10 cm
Way of growth.....	small glades	scat- tered	clus- ters	clus- ters	clus- ters
<i>Populus balsamifera</i>		near plot		+	
<i>Populus tremuloides</i>		near plot			
TALL SHRUB LAYER					
<i>Betula glandulosa</i>				+	
<i>Larix laricina</i>	+	+		+	
<i>Picea mariana</i>	+	+	+	++	dead
<i>Populus balsamifera</i>				+	
<i>Salix glauca</i>	+			+	+
<i>Salix</i> sp.....		+			
FIELD LAYER					
Low shrubs and dwarf shrubs					
<i>Arctostaphylos rubra</i>				+	
<i>Empetrum hermaphroditum</i>	+			+	
<i>Geocaulon lividum</i>			+	+	
<i>Juniperus communis</i> var. <i>depressa</i>	+				
<i>Juniperus horizontalis</i>				+	
<i>Ledum groenlandicum</i>	++		+	+	++
<i>Linnaea borealis</i> var. <i>americana</i>			+	+	
<i>Lonicera villosa</i>		+			
<i>Lycopodium annotinum</i> var. <i>alpestre</i>	+				
<i>Potentilla fruticosa</i>		+	+	+	
<i>Ribes glandulosum</i>					+
<i>Ribes triste</i>		+		+	
<i>Rhamnus alnifolia</i>				+	
<i>Rosa acicularis</i>	+	+	+	+	+
<i>Salix myrtillifolia</i>				++	
<i>Salix vestita</i>				+	
<i>Salix</i> sp.....		+			
<i>Shepherdia canadensis</i>	+				
<i>Vaccinium caespitosum</i>		}++{	+		+
<i>Vaccinium myrtilloides</i>	+				+
<i>Vaccinium uliginosum</i>					
<i>Vaccinium Vitis-Idaea</i> var. <i>minus</i>	+			+	+
<i>Viburnum edule</i>	+				
Herbs					
<i>Achillea borealis</i> ("nigrescens").....			+	+	
<i>Anemone parviflora</i>				+	

TABLE 2.—Continued

	1	2	3	4	5
FIELD LAYER—concluded					
Herbs—concluded					
<i>Aster ciliolatus</i>	+		+	+	
<i>Castilleja septentrionalis</i>				+	
<i>Chamaenerion (Epilobium) angustifolium</i>	+	+	+	+	+
<i>Corallorrhiza trifida</i>			+		
<i>Cornus canadensis</i>			+		+
<i>Corydalis sempervirens</i>					+
<i>Fragaria virginiana</i>		+	+	+	
<i>Halenia deflexa</i>				+	
<i>Mitella nuda</i>		+	+	+	
<i>Petasites palmatus</i>		+	+	+	+
<i>Pyrola ? grandiflora</i>				+	
<i>Rubus acaulis</i>		+	+	+	
<i>Senecio pauperculus</i>				+	
<i>Solidago multiradiata</i>	+		+	+	+
<i>Valeriana septentrionalis</i>				+	
<i>Viola adunca</i>			+	+	
<i>Viola pallens</i>			+	+	
Herbaceous grass-like plants					
<i>Agropyron trachycaulon</i> (var.).....				+	
<i>Calamagrostis canadensis</i>					+
<i>Carex concinna</i>				+	
<i>Carex deflexa</i>					+
<i>Carex scirpoidea</i>				+	
<i>Carex vaginata</i>		+		++	
<i>Carex</i> spp.....		+			+
<i>Elymus innovatus</i>	+				
<i>Equisetum pratense</i>		+		+	
<i>Oryzopsis pungens</i>			+		
<i>Schizachne purpurascens</i>			+		
Unidentified grasses.....		+		+	+
BOTTOM LAYER					
Bryophytes					
<i>Aulacomnium palustre</i>		++	++	+	
<i>Campylium chrysophyllum</i>				+	
<i>Ceratodon purpureus</i>					++
<i>Dicranum Bergeri</i>		+	+	+	
<i>Dicranum Bonjeanii</i>			+		
<i>Dicranum Drummondii</i> C.M.....				+	
<i>Dicranum fuscescens</i>				+	
<i>Dicranum Muehlenbeckii</i>				+	
<i>Dicranum polysetum</i> Sw. (= <i>undulatum</i>).....	+		+		
<i>Dicranum spadiceum</i>				+	
<i>Ditrichum flexicaule</i>			+	+	
<i>Drepanocladus uncinatus</i>			+		
<i>Hylocomium splendens</i>	+	++	++	++	
<i>Pleurozium Schreberi</i>	++	++	+	+	
<i>Pohlia (Webera) nutans</i>	+				+
<i>Polytrichum juniperinum</i>					+
<i>Polytrichum piliferum</i>					+
<i>Ptilidium ciliare</i>	+				
<i>Ptilium crista-castrensis</i>			+	+	

TABLE 2.—Concluded

	1	2	3	4	5
BOTTOM LAYER—concluded					
Bryophytes—concluded					
<i>Tomentypnum nitens</i>			+	+	
Undetermined hepatic.....					+
Lichens					
<i>Cladonia alpestris</i>	++	+	+	+	} dead
<i>Cladonia rangiferina</i>	++	+		++	
<i>Cladonia silvatica</i> (agg.).....	+		+	++	
<i>Cladonia</i> spp.....	+		+	+	+
<i>Nephroma arcticum</i>	+				
<i>Peltigera aphthosa</i>	+	+	+		
<i>Peltigera leucophlebia</i>				+	
<i>Stereocaulon tomentosum</i>			+		

- 1. East shore of northern part of Hawley Lake, on a rather dry site sloping somewhat toward the West.
- 2. About 400 m from the same shore, close to a small brook, seasonally moist but fairly well drained, one of the best sites for forest growth in the area.
- 3. Close to (1) but 200 m back from the lake, less sloping and markedly moister, with better forest growth than in (1).
- 4. Seasonally wet open forest on west side of Hawley Lake, edge of plateau. In surrounding black spruce forest the largest trees are 12 to 15 m high, with a breast height diameter of 20 and 27 cm, respectively.

The "*Cladonia* spp." of this plot include: *C. cornuta*, *C. deformis*, *C. degenerans*, *C. gracilis* var. *chordalis*, and *C. turgida*.

Soil profile: 0-15 cm A₀(F) dark, nearly black, fibrous mor (raw humus), rich in mycelia in upper part, pH at 2-4 cm 6.2, also rich in roots and mycorrhiza; ground water occurred at 15 cm, pH (humus) 7.4; 15-27 cm A₀(H), black greasy wet humus, pH at 20 cm 7.5; below 27 cm C, mineral soil with mollusc shells, pH at 27-29 cm 7.5, at 32 cm 7.8, only at 32 cm effervescent with HCl. Profile frozen (July 5) between 20 and 33 cm. All pH values determined electrometrically the same day, one part of fresh soil diluted with two parts distilled water and filtered after occasional shaking in the course of several hours.

- 5. Only 50 m from (4) on a burn which occurred in 1948. The forest stand appeared to have been lower, possibly younger and somewhat denser than in (4). Soil drier with abundant lichens before the burn. Only living plants recorded. Most of the plants of the burnt area have survived the fire by subterranean parts (cf. for instance Uggla, 1958), but the tree seedlings, *Corydalis sempervirens*, *Carex deflexa*, and the bryophytes are newcomers, as are probably also the *Ribes* spp.

Outside the sample plot, numerous other plants were noted in the burnt area, e.g. seedlings of black spruce and balsam poplar, *Salix Bebbiana*, *Ribes hudsonianum*, *R. triste*, *Lonicera involucrata*, *Arctostaphylos Uva-ursi* var. *coactilis*, *A. rubra*, *Equisetum arvense*, *Agrostis scabra*, *Agropyron trachycaulon*, *Oryzopsis pungens*, *Schizachne purpurascens*, and *Anemone multifida*.

Soil profile: 0-6 cm A₀, dark brown mor (raw humus), pH 5.3, with remains of lichens on top, and rhizomes of *Vaccinium* and *Ledum*; 6-9 cm A₁, leached greyish sand, pH 5.4; 9-35 cm B, sand with some gravel rather strongly rust-coloured in upper part, pH 6.2, less so below, pH 6.3; 35-45 cm C, nearly unchanged calcareous sand, pH 7.7, eff. w. HCl, with mollusc shells; below 45 cm C, sand and fine sand, calcareous, yellowish, pH 7.7, eff. w. HCl, with mollusc shells. Unfrozen.

As stated above, the vegetation, particularly on wet areas, has a considerable admixture of more or less calciphilous plants, such as *Potentilla fruticosa* (2, 3, 4), *Ditrichum flexicaule* (3, 4), *Tomentypnum nitens* (3, 4),

Equisetum scirpoides (4, 5), *Juniperus horizontalis* (4), *Salix vestita* (4), *Anemone parviflora* (4), *Castilleja septentrionalis* (4), *Senecio pauperculus* (4), and *Carex scirpoidea* (4). However, the preference for or confinement to calcareous soils of these and some other species needs to be confirmed by further ecological studies. Species such as *Potentilla fruticosa* have strong root systems that may reach the calcareous subsoil even in superficially well-leached sites. In large areas of very poorly developed open black spruce woodland on seasonally wet soil, this species is a dominant, co-dominant, or sub-dominant together with other shrubs, e.g. Labrador tea (*Ledum groenlandicum*), junipers, willows, and occasionally *Lonicera involucrata*. There occur also peatland species, e.g. *Andromeda polifolia*, *Kalmia polifolia*, and *Chamaedaphne calyculata*. Rare, but typical of the wet woodland, are *Coptis groenlandica*, *Polygala pauciflora*, and *Ranunculus lapponicus*, and in *Sphagnum fuscum* cushions the minute *Pinguicula villosa* may be found. The frequent combination of such species as *Rosa acicularis*, *Potentilla fruticosa*, and *Carex scirpoidea* (sample plot 4) seems very strange to a European botanist accustomed to the restricted European ranges of these plants.

CLASSIFICATION OF PEATLAND VEGETATION

As noted elsewhere (Sjörs, 1959), there is a striking parallelism in the composition of peatland vegetation in Northern Europe and Eastern Canada. As many as 60 per cent of the species composing the vascular flora may be common to both. The parallelism is even more striking in the cryptogamic flora of peatlands where all but a few important bryophytes and lichens are common to the two continents. For this reason classification of peatland vegetation in parts of Europe having comparable physiographic conditions applies equally well at least to northern and eastern parts of Canada. Whereas in Europe the study of peatland has been a well-developed science for sixty years, there are as yet few important contributions from the New World, where some students of peatland seem reluctant to apply European experience to specific North American problems. Thus Radforth, in a series of papers, almost seems to treat the "organic terrain" as if it were a feature unique to the Canadian North. On the other hand, Drury (1956) and Hamelin (1957) discuss certain European papers extensively.

It would seem worth while to try a direct application of concept and terms developed in Europe, notably in Scandinavia, to boreal and sub-arctic Canadian peatlands. In Western and Central Europe, physiographic conditions are less comparable than are those of subcontinental Fennoscandia (and Northern Russia, where, unfortunately, most of the literature is in Russian and therefore as inaccessible to the present author as are papers in Finnish and Swedish to most American students of peatland). This, however, is not the place for a full discussion of these concepts and terms.

It should perhaps be noted that the classification of peatlands and their vegetation is, in any case, somewhat arbitrary. There are rather numerous "directions of variation" within the peatland vegetation as discussed by Sjörs (1950b). Therefore, the system of Du Rietz, followed here, is by no means the only valid one. There are, in fact, several different systems in current use among the small group of Fenno-Scandinavian students of peatland. For instance, the widely used Cajander (1913) classification of peatland vegetation, if stripped of some of the over-specialization added by later authors and adjusted to the differing floras, may prove equally useful in Canada and Finland.

The Du Rietz system of classification of the vegetation of Swedish peatlands (or, more correctly, mires; cp. p. 13), was published in full in 1949 (short summary in English). Details were given, in 1950, in some excursion guides, and further refinements of the system appeared later (1954b, in German). The words "minerotrophic" and "ombrotrophic" were introduced in the latter paper, although the concepts themselves are much older, the difference having been noticed already by some of the earliest investigators (esp. Dau, 1823). Important landmarks in the development of the theory were the recognition by Weber, in 1909 (1911, p. 8), of ombrogenous peatland and the distinction proposed by Thunmark in 1935 (1940, 1942) of a mineral soil water limit. One may also refer to Sjörs (1950a and b, 1952) and to the English summaries (Sjörs, 1946 and 1948).

According to the system of Du Rietz, there are two main units of mire vegetation. One is the *bog vegetation* peculiar to *ombrotrophic* peatland, in which the water supply is derived solely from the precipitation on the ombrotrophic area itself, because water from mineral soil is unable to reach the surface and the uppermost peat strata. In the classical raised bog the surface is up-domed, but other types of relief may occur which prevent access of mineral soil water. The ombrotrophic water is highly deficient in mineral salts. This leads to a low metal ion saturation of the peat acids and acidoids, a very low pH value, and a general mineral deficiency for the plants. This all results in a highly specialized bog vegetation, poor in vascular species.

The *fen vegetation*, on the other hand, develops when conditions are *minerotrophic*, i.e. in mire areas reached by ground water that has percolated through mineral soil. Even when the minerotrophic influence is slight, it will be possible to trace it through the presence of obligate fen species. (In close proximity to the sea, the presence of large quantities of wind-carried salts, also on ombrotrophic peatland, may cause difficulties which make this idea less easy to apply; but this is not relevant for the present study.) British and Scandinavian authors generally apply the word "fen" to minerotrophic peatland, although opinions differ regarding the extent to which one should include sites where the minerotrophic influence is weak. This happens in peatland fed by weakly minerotrophic

water from silicious soils, in particular if the supply of minerotrophic water is small or intermittent. Under such conditions the minerotrophic peatland will be more or less acid.

A great number of plants needing minerotrophic water cannot grow under ombrotrophic conditions, except in close proximity to the sea. It is easily observed that such plants are practically always absent if the hydrology of the peatland is strictly ombrotrophic. In a given area the presence or absence of fen indicators, i.e. indicators of minerotrophy, is nearly always conclusive. There are, however, a few species of inconclusive preference, among them *Carex pauciflora*, which, although sometimes present (but frequently sterile) in certain bog areas, grows much more abundantly in fens (except in calcareous areas, where it may be found in the more acid *Sphagnum* cushions). Another doubtful case is *Eriophorum russeolum*, which, in addition to wet fens, grows in bog pools perhaps deep enough to have some slight contact with minerotrophic peat or subsoil, presumably through frost cracks formed in winter, or through disturbance caused by rising ice or methane gas, or to the occasional collapse or erosion of palsas (p. 27).

In the Hudson Bay area *Menyanthes trifoliata* appears to be a particularly useful indicator of even slight minerotrophy. Other sensitive indicators are *Betula glandulosa*, *Myrica Gale*, *Potentilla palustris*, *Carex chordorrhiza*, *Equisetum fluviale*, *Utricularia intermedia*, *U. minor*, and *U. vulgaris*. The majority of fen indicators in the Hawley Lake area belong to a much more demanding, and even calciphilous type ("rich fen indicators", see below).

In the Hawley Lake district the subsoil is nearly always highly calcareous. The minerotrophic ground water, therefore, is often saturated with calcium bicarbonate, and when exposed to the air or to heat gives off carbon dioxide so that calcium carbonate is deposited in the minerotrophic peatland. For this reason the contrast between minerotrophic and ombrotrophic peatland, is, no doubt, sharper and more noticeable here than is the rule in Precambrian, silicious parts of Canada. In Hawley Lake fens, weakly calcareous conditions are found only in the numerous *Sphagnum fuscum* cushions which cover part of the peatlands, and near the borders of minerotrophic peatland toward ombrotrophic areas in "laggs", i.e. fen belts separating bog from mineral soil (No. 11 in Table 3).

Bog and fen vegetation very frequently occur together in "mire complexes" (Cajander 1913). The little-known English word "mire" has been tentatively used for bog + fen. This is a somewhat broader concept than the more easily understood "peatland". Some "mire" vegetation does not actually form peat or grow on peat; this, for example, is the case in the shallow calcareous pools in the Hawley Lake fens. It would be tempting to replace "mire" with the Indian word "muskeg", which is now widely used in Canada, but, unfortunately, this word has quickly shared the fate of numerous other vernacular words that, when used in technical writing, tend to become ambiguous when an attempt is

made to apply them in a restricted sense. Muskeg is frequently used for the "black spruce muskeg", a widespread kind of swampy woodland. Radforth's "organic terrain" has hardly any advantage over "peatland" but may run the risk of being loosely extended to terrestrial sites with fairly thick humus cover, such as are found in certain types of forest or tundra.

THE FENS

Fen vegetation is divided by Du Rietz into "poor fen" and "rich fen" vegetation. The former, which is clearly acidophilous, is probably almost absent in the Hawley Lake district but is a common type of vegetation in the silicious Precambrian landscape. In calcareous areas the "rich fen" type prevails and at Hawley Lake seems to be ubiquitous in minerotrophic peatland, generally developed as the more decidedly calciphilous variety, the "extremely rich fen".

Some bryophytes, notably *Bryum ovatum*, *Leiocolea Muelleri*, *Ditrichum flexicaule*, *Meesia uliginosa*, and *Catoscopium nigrum*, are indicators of "extremely rich fen" in Fennoscandia as well as in Canada. Many bryophytes are indicators of all types of "rich fen," e.g. the important dominants *Scorpidium scorpioides*, *Drepanocladus intermedius*, *Campylium stellatum*, *Tomentypnum nitens*, and *Sphagnum warnstorffianum*. (The latter two or three grow also in wet forest.) Also *Calliergon giganteum*, *C. trifarium*, *Drepanocladus tundrae*, *Cinclidium stygium*, *Paludella squarrosa*, and the hepatic *Leiocolea rutheana* (= *L. Schultzii*) may belong in this group, together with two species not found in Europe: the falcate *Tomentypnum*¹ *nitens* var. *falcifolium* (Ren. ex Nichols.) Persson & Sjörs (1960), and *Mnium andrewsianum* Steere (1958).

The truly calcicolous, non-arctic vascular plants frequently have a more restricted world distribution than have other vascular "mire" species. The reason for this may be historical. It is therefore sometimes necessary to use different vascular "indicator species" for the "extremely rich fens" of Canada and Fennoscandia.

Quite typical "extremely rich fen" indicators in the Hawley Lake district are the local representative of *Triglochin maritimum* (agg.)², *Eriophorum brachyantherum* (probably a general "rich fen indicator" in Fennoscandia), *Carex microglochin* (extremely rich fen indicator also in Fennoscandia), *Kobresia simpliciuscula*, *Carex scirpoidea*, and *Potentilla fruticosa* (the last three are calcicoles of restricted distribution in Fennoscandia), *Juncus albens* (vicarious for *J. triglumis* of extremely rich fens in northern and alpine parts of Fennoscandia) and, finally, *Primula mistassinica*, *Carex gynocrates*, *Erigeron hyssopifolius*, *Juniperus horizontalis*, *Platanthera hyperborea*, and *Tofieldia glutinosa*, none of which occurs in Fennoscandia.

¹ *Camptothecium nitens* var. *falcifolium* Ren. ex Nichols. = *C. nitens* var. *falcatum* Burnham. Prof. R. Tuomikoski of Helsinki regards this moss as a distinct species. His opinion is shared by Persson & Sjörs (1960). Besides the station east of Hawley Lake (Table 3, No. 9), this moss was found in abundance in two localities near the junction of Muketui and Attawapiskat rivers; in two of the three stations it grew together with *T. nitens*, but was easily separable from it.

² Probably *T. debile* (M. E. Jones) Löve & Löve. The European *T. maritimum* L. (s. str.) is almost exclusively a sea-shore or saline plant. Cf. Löve & Löve (1958).

TABLE 3. NOTES FROM RICH FEN: (1-4) AT WINISK, (5) AT SUTTON NARROWS, (6-11) AT HAWLEY LAKE; (1-10) FROM EXTREMELY RICH FEN, (11) FROM MODERATELY RICH FEN, AT THE LIMIT OF MINERAL SOIL WATER (Notes incomplete).

	1	2	3	4	5	6	7	8	9	10	11
pH (surface water).....	7.2	7.6	7.5	7.1	8.2	8.0	8.3	8.3	7.1	7.8	4.1
DWARF TREE LAYER											
<i>Larix laricina</i> (4 m or less)				++	+		+	+		+	
<i>Picea mariana</i> (3 m or less; b = burnt).....				+	+	b		+			
FIELD LAYER											
Low shrubs and dwarf shrubs											
<i>Alnus crispa</i>						+					
<i>Andromeda polifolia</i>	+	+	+	+	+		+		+	+	
<i>Arctostaphylos rubra</i>						+					
<i>Betula glandulosa</i>	+	+	+	+	+	+	+		+	+	
<i>Chamaedaphne calyculata</i> ..									+		+
<i>Empetrum hermaphroditum</i>								+			
<i>Juniperus communis</i> var. <i>depressa</i>								+			
<i>Juniperus horizontalis</i>					+			+			
<i>Kalmia polifolia</i>								+		+	+
<i>Larix laricina</i>	+	+	+	+				+	+		
<i>Ledum groenlandicum</i>				+				+			
<i>Lonicera villosa</i>				+							
<i>Myrica Gale</i>	+	+	+	+							
<i>Oxycoccus microcarpus</i>	+		+	+					+		+
<i>Oxycoccus quadripetalus</i> ...		+		+					+		+
<i>Potentilla fruticosa</i>		+		+		+		+			
<i>Salix pedicellaris</i> var. <i>hypoglauca</i>	+	+	+		+	+		+	+		
<i>Salix vestita</i>				+	+						
<i>Vaccinium uliginosum</i>		+					+	+			
Herbs											
<i>Bartsia alpina</i>					+						
<i>Cardamine pratensis</i> (agg.)	+										
<i>Cornus canadensis</i>								+			
<i>Drosera anglica</i> var. <i>pusilla</i> Kihlm.....					+		+				
<i>Drosera rotundifolia</i>					+				+		
<i>Epilobium palustre</i>	+				+						
<i>Erigeron hyssopifolius</i>					+	+					
<i>Galium</i> sp. (<i>labradoricum</i> ?)		+							+		
<i>Menyanthes trifoliata</i>	+				+		+		+	+	+
<i>Parnassia palustris</i>					+						
<i>Pedicularis</i> sp.....		+									
<i>Pinguicula vulgaris</i>					+						
<i>Platanthera</i> (<i>Habenaria</i>) <i>hyperborea</i>					+	+					
<i>Polygonum viviparum</i>		+	+								
<i>Potentilla palustris</i>	+				+						
<i>Primula mistassinica</i>						+		+			
<i>Pyrola asarifolia</i> var. <i>purpurea</i>					+	+					
<i>Ramischia</i> (<i>Pyrola</i>) <i>secunda</i> var. <i>obtusata</i>								+			
<i>Rubus acaulis</i>	+	+				+			+		

TABLE 3.—Continued

	1	2	3	4	5	6	7	8	9	10	11
pH (surface water).....	7.2	7.6	7.5	7.1	8.2	8.0	8.3	8.3	7.1	7.8	4.1
FIELD LAYER—Concluded											
Herbs—Concluded											
<i>Selaginella selaginoides</i>					+			+	+		
<i>Smilacina trifolia</i>		+	+	+	+		+			+	+
<i>Tofieldia glutinosa</i>					+		+				
<i>Tofieldia pusilla</i>					+		+				
<i>Viola</i> sp.....								+			
Herbaceous, grass-like plants											
<i>Calamagrostis neglecta</i>					+						
<i>Carex capillaris</i>					+			+			
<i>Carex chordorrhiza</i>	++	+	+	+	+		+			+	
<i>Carex gynocrates</i>					+						
<i>Carex limosa</i>		++			+		++			+	++
<i>Carex microglochin</i>					+						
<i>Carex oligosperma</i>	+										
<i>Carex scirpoidea</i>					+						
<i>Carex vaginata</i>					+			+			
<i>Carex</i> spp.....			+	+	+	++	+	+	++	+	
<i>Equisetum fluviale</i>	+	+	+	+					+	+	
<i>Equisetum scirpoides</i>					+	+		+			
<i>Equisetum variegatum</i>			+		+		+	+			
<i>Eriophorum angustifolium</i> ..							+				
<i>Eriophorum brachyantherum</i>					+	+					
<i>Eriophorum russeolum</i>								+			
<i>Juncus albescens</i>					+	+		+			
<i>Juncus alpinus</i> var.											
<i>rariflorus</i>						+		+			
<i>Juncus castaneus</i> ?.....					+						
<i>Kobresia simpliciuscula</i>										+	
<i>Muhlenbergia glomerata</i>					+						
<i>Trichophorum alpinum</i>											
(<i>Scirpus hudsonianus</i>)...					+		+		+		
<i>Trichophorum cespitosum</i>											
v. <i>austriacum</i>			++		++		+		++	+	
<i>Triglochin maritimum</i>											
(agg.).....			+		+		+	+	+	+	
<i>Triglochin palustre</i>						+					
Aquatics											
<i>Potamogeton gramineus</i>								+			
<i>Utricularia intermedia</i>					+					+	
<i>Utricularia minor</i>									+		
<i>Utricularia vulgaris</i>					+						
BOTTOM LAYER											
Bryophytes											
<i>Aulacomnium palustre</i>				+					+		
<i>Brachythecium turgidum</i> ...						+					
<i>Blepharostoma trichophyllum</i>						+					
<i>Bryum ovatum</i> Jur.....			+		+						
<i>Bryum pseudotriquetrum</i> ...			+	+							
<i>Calliergon giganteum</i>		+	+	+		++		+			
<i>Calliergon stramineum</i>											+
<i>Calliergon trifarium</i>							+	+			
<i>Campylium stellatum</i>	+		+	+	++	+	+	+	++	++	
<i>Catocopium nigratum</i>					+					+	

TABLE 3.—*Concluded*

	1	2	3	4	5	6	7	8	9	10	11
pH (surface water).....	7.2	7.6	7.5	7.1	8.2	8.0	8.3	8.3	7.1	7.8	4.1
BOTTOM LAYER— <i>Concluded</i>											
Bryophytes— <i>Concluded</i>											
<i>Cephalozia media</i>											+
<i>Cephalozia pleniceps</i>											+
<i>Cinclidium stygium</i>	+		+					+			
<i>Ditrichum flexicaule</i>					+			+		+	
<i>Drepanocladus intermedius</i>	+		+	+	+	++	++	+	+	++	
<i>Drepanocladus procerus</i>				+							++
<i>Drepanocladus revolvens</i> s. str.....											+
<i>Drepanocladus tundrae</i>		+									
<i>Fissidens adianthoides</i>								+			
<i>Hylocomium splendens</i>						+		+			
<i>Hypnum Bambergeri</i>								+			
<i>Hypnum Lindbergii</i>				+		++					
<i>Leiocolea Muelleri</i>						+					
<i>Leiocolea rutheana</i> (Schultzii).....			+	+					+		
<i>Lophozia marchica</i>											+
<i>Meesia tristicha (triquetra)</i>			+		+			+			
<i>Meesia uliginosa</i>					+						
<i>Microlepidozia setacea</i>						+					
<i>Mnium andrewsianum</i> Steere (1958).....				+							+
<i>Paludella squarrosa</i>				+							
<i>Pohlia (Webera) nutans</i>				+							
<i>Riccardia latifrons</i>											+
<i>Riccardia pinguis</i>			+						+	+	
<i>Scapania hyperborea</i>				+							
<i>Scorpidium scorpioides</i>	+	++	++		+		++	+	++	++	
<i>Sphagnum parvifolium</i>									+		+
<i>Sphagnum warnstorffianum</i> ..				++				+	+		+
<i>Tomentypnum nitens</i>			+	++	+	+		+	++		+
<i>Tomentypnum nitens</i> v. <i>falcifolium</i> (Ren. ex. Nich.) Persson & Sjörs (1960).....									+		

1 and 3—About 1 mile W. of Winisk, wet open fen. 2—Same, very wet. 4—Same, drier *Larix* fen. 5—W. of Sutton Narrows, calcareous wet slope and edge of shallow pool with calcareous algal mud. 6—W. of Hawley Lake, sloping spring fen with calcareous deposits. 7—Same, fen with flarks and shallow round calcareous pools. 8—Same, edge of shallow round calcareous lake. 9—E. of Hawley Lake, “lagg” of a palsa bog. 10—W. of Hawley Lake, middle of “lagg” of the palsa bog described in some detail (p. 22). 11—Same, moderately rich fen at the edge of the “lagg” toward the bog; pH sample 1 m from borderline. Another water sample taken exactly on the boundary gave pH 4.0. These low values show that at the time of sampling more water was seeping from the bog than derived from the fen. The vegetation indicates that the situation may be the reverse at intervals.

Because “moderately rich fen” (Du Rietz, 1954a) is much less common in the Hawley Lake area than is “extremely rich fen”, it is not always easy to determine whether a given species is indicative of both or only of the latter. In this category belong *Equisetum variegatum*, *E. scirpoides*,

Parnassia palustris, *Pinguicula vulgaris*, *Selaginella selaginoides*, *Trichophorum alpinum* (= *Scirpus hudsonianus*), *Triglochin palustre*, and *Tofieldia pusilla*, all occurring primarily in rich fen vegetation in Fennoscandia, but not restricted there to the "extremely rich fen".

Owing to the shortness of our visit (June 23 to July 5) when, moreover, because of the proximity of the ice-filled Hudson Bay, the vegetation was little advanced for the time of year, our notes and collections from the fens near Hawley Lake are very incomplete. These fens are very variable; the larger ones are strongly "patterned" by a network of brownish *Sphagnum fuscum* hummocks, one to two feet high, separating broad, mud-bottomed depressions. The latter are of variable size and of irregular or roundish shape with light brown to almost whitish bottoms and may dry up partly in rainless periods later in the summer. These well-differentiated mud-bottom depressions, when occurring in fens, are termed "*flarks*" or "*rimpis*" (the former word is of Swedish origin, the latter of Finnish). They are a well-known feature of the patterned peatland of the high boreal and subarctic circumpolar zones. Elsewhere the arrangement of the flarks is step-wise, and the flark complex is localized to strips or broad passages of strong seepage ("water tracks"). These features are not very clear in the Hawley Lake area, as air photographs show a fairly uniform distribution of flarks over the large fen areas. The flarks here do not show up so clearly in black-and-white as is the case when they have dark bottoms, which is the rule in less calcareous fens.

Another type of fen was seen near some brooks and lakes where the surface was very wet and so soft that it was not possible to explore it on foot. We also noted small, firm, distinctly sloping areas in the open fen. Whereas these two types do not differ much floristically from the ordinary "extremely rich fen", some fens watered by calcareous spring water are more distinct in this respect. Among the vascular species noted on such spring fens were *Erigeron hyssopifolius*, *Primula mistassinica*, *Juncus albens*, *J. alpinus* var. *rariflorus*, *Eriophorum brachyantherum*, *Rubus acaulis*, and *Salix vestita*. Most of these also grow on lake shores, as does the moss *Hypnum Lindbergii*. Calcium carbonate is deposited abundantly in this type of fen, which occupies small, sloping depressions usually surrounded by black spruce woodland.

In Table 3 are listed the species noted in certain areas of rich fen; however the records do not represent complete vegetation analyses.

TOPOGRAPHY AND VEGETATION OF PALSA BOGS

Ombrotrophic conditions around Hawley Lake are confined to a number of distinctly marked roundish bogs which are hardly raised but nevertheless are not reached by any minerotrophic water. On the plateau a few miles to the east these bogs are large and numerous. Some may be as much as a mile across, but most of them are smaller. They are not concentrically domed as are typical "raised bogs", but slope somewhat unilaterally. Hydrotopographically they may be considered transitional between "raised bogs" and "blanket bogs". Comparable bogs have been described recently from the Silver Flowe in southwest Scotland (Ratcliffe and Walker, 1958). The Hawley Lake bogs even better match some types of slightly sloping, yet usually purely ombrotrophic bogs, found in western, central, and, less frequently, northern Fennoscandia. Examples

of the latter are Osvald's "planmosse" (flat bog), in part (Osvald, 1930); the "moss built up eccentrically" described by Sjörs (1948, pp. 194-227, 280); and certain bogs in Finland described by Aario (1932). Large bog-pools (hollow-pools) are found in the central parts of many of these British and Scandinavian bogs, as well as in the larger ones at Hawley Lake, particularly those on the eastern plateau. However, the Hawley Lake bogs are situated in a region in which the winter climate is definitely colder than in the parts of Europe in which we find bogs having a similar or comparable hydrotopography. This is evident from the presence of frozen peat-mounds, which have no counterpart in the previously mentioned parts of Europe. In Europe such low peat-mounds, known by the Finnish word "*palsa*", are found in the northernmost parts of Russia, Finland, and Sweden (Lundqvist, 1951). The palsas of northernmost Fennoscandia, however, are not found on otherwise ombrotrophic sites but commonly occur between wet minerotrophic areas, i.e. fen and fen-pools; such a complex is often regarded as a kind of "mixed mire" in Fennoscandia. At Hawley Lake, on the other hand, the areas between the palsas are normal ombrotrophic bog, consisting of small areas of *Sphagnum fuscum* hummocks (with long-lasting, seasonal, but not perennial frost), rather large hollows, and bog-pools.

Palsas are perennially frozen peat-mounds of moderate size, generally much less than 100 m across and from one to several metres high. The Fennoscandian palsas are treeless because they are found mainly within the subalpine-subarctic birch zone that in Fennoscandia extends beyond the upper and polar limit of conifers. Most palsas of the northern Hudson Bay lowland support a few stunted tamaracks or black spruces, the latter commonly forming low thickets; in both species the lower branches are rooting freely. In most palsas, the summit areas are frequently covered only by lichens. The condition of the vegetation on the summits and upper parts of the sides, especially those facing north and northwest, suggests a scanty snow cover in winter. This undoubtedly is the reason that permafrost is able to persist within the mounds in a region in which permafrost is otherwise absent.

Farther south and inland, within the Hudson Bay lowland, palsas are replaced by a peculiar and quite different type of raised permafrost structure, the "black spruce islands". They are commonly surrounded by fen or situated along brooks, and covered by low but dense black spruce forest; generally they are much wider than the palsas (Hustich 1957, Sjörs 1959). As "black spruce islands" do not occur near Hawley Lake, they will be discussed in a future paper, dealing with the Attawapiskat River area. Palsas should not be confused with the true pingos found in some areas with continuous permafrost. Pingos are not known to occur in the Hudson Bay lowland. They are usually much larger and higher than the palsas, and their genesis is different (Porsild 1938).

Palsas occur mainly in the central areas of the Hawley Lake bogs, but not, as a rule, in the parts having the largest bog-pools. The most impressive palsa areas, very likely with a relief of several metres, were seen from the air on the eastern plateau, where the palsas show up as white granules in air photographs taken from an elevation of 30,000 feet. Two smaller palsa bogs were visited, one on the east side of the lake, and one on the west side. Analyses of their vegetation are given in Table 4. In the eastern bog (Nos. 1-3) the palsas are low and do not differ much from



A. Low eroded palsa in bog east of Hawley Lake. Dominant in the foreground: *Chamaedaphne calyculata*, with *Andromeda polifolia*, *Kalmia polifolia*, and *Eriophorum spissum*; in the water *Sphagnum Dusenii* and some *S. Lindbergii*.



B. Palsa bog west of Hawley Lake. In the foreground *Larix laricina*, *Eriophorum spissum*, *Carex limosa*, etc.

ordinary bog hummocks, except that *Sphagnum* is lacking in the vegetation of the higher parts. In shallow bog-pools grows *Scheuchzeria palustris*, otherwise not seen in the Hawley Lake area. *Eriophorum spissum*, likewise, was seen only in ombrotrophic bogs; elsewhere both occur also in acid, weakly minerotrophic fens. *Rubus chamaemorus*, too, is found in *Sphagnum* cushions elsewhere, so that none of the vascular species listed in Table 4 is strictly confined to ombrotrophic areas. Although not included in the list, *Smilacina trifolia* was found in these bogs, and *Pinguicula villosa* may be expected to occur there but actually was found but once in the Hawley Lake area, in a *Sphagnum fuscum* cushion, in wet woodland.

TABLE 4. VEGETATION OF PALSA BOGS AT HAWLEY LAKE. SMALL TYPICAL AREAS.

[illegible]

TABLE 4.—*Concluded*

	1	2	3	4	5	6	7	8	9	10	11
pH (surface water).....			4.3							4.1	4.5
BOTTOM LAYER— <i>Concluded</i>											
Bryophytes— <i>Concluded</i>											
<i>Dicranum elongatum</i>				+							
<i>Drepanocladus Schulzei</i> ¹ ...		+	+						+		
<i>Gymnocolea inflata</i>			+				+	+		++	
<i>Lophozia marchica</i>							+				
<i>Lophozia ventricosa</i>	+										
<i>Microlepidozia setacea</i>							+				
<i>Mylia anomala</i>	+	+					+	+			
<i>Pleurozium Schreberi</i>	+										
<i>Pohlia (Webera) nutans</i>	+										
<i>Polytrichum affine (strictum)</i>	+			+	++		+				
<i>Sphagnum balticum</i>		++					+	++	++	+	
<i>Sphagnum compactum</i>		+									
<i>Sphagnum Dusenii</i>			++					+	+	+	
<i>Sphagnum fuscum</i>	++						++	+			
<i>Sphagnum Lindbergii</i>			+					+	++	+	
<i>Sphagnum robustum</i>	+	+									
<i>Sphagnum rubellum</i>	+	+					+	+			
<i>Sphagnum tenellum</i>								+	+		
Lichens											
<i>Cetraria islandica</i> (incl. var. <i>crispa</i>).....				+							
<i>Cetraria nivalis</i>				+	+						
<i>Cladonia alpestris</i>	++			+	+	++	++	+			
<i>Cladonia amaurocraea</i>	+			++	+		+				
<i>Cladonia rangiferina</i>	++			++	++	+	++				
<i>Cladonia silvatica</i> (agg.)...	+			++	++		++	+			
<i>Icmadophila ericetorum</i>	+			+			+				
<i>Ochrolechia frigida</i>	+	+									
Other lichens.....	+	+		++	+		+				

1 to 3—Bog E. of Hawley Lake: 1—Low palsa and hummock, "other lichens": *Cladonia coccifera*, *C. crispata*, *C. deformis*; 2—Edge of hummock, "other lichens": *Cladonia squamosa*; in marginal part of bog *C. Delessertii*; 3—Hollow and shallow hollow-pool. 4 to 11—Bog W. of Hawley Lake: 4—Palsa, lichen cover, "other lichens": *Alectoria nidulifera*, *Cladonia coccifera*, *C. deformis*, *C. pyxidata*, *Mycoblastus sanguinarius*, *Ochrolechia* sp. (not *frigida*), *Parmelia physodes*, *Pertusaria* sp., *Sphaerophorus globosus*; 5—Palsa, dwarf shrub and lichen cover, "other lichens": most of those found in (4); 6—Palsa, black spruce cover; 7—Hummock, "other lichens": *Cladonia crispata*; 8—Hollow, firm peat with tussock vegetation; 9—Hollow, soft carpet; 10—Hollow, mud-bottom; 11—Hollow-pool.

The vegetation was studied in greater detail in the western palsa-bog which is about a quarter of a mile across. Like the eastern bog, it is separated from mineral ground on the lakeward side by a strip of fen (a "lagg" in the sense of European authors), through which minerotrophic water is carried past the bog (compare Table 3, Nos. 10 and 11). On the south and west sides of the western bog are wet fens and a small lake. The bog evidently has developed on a local watershed causing minerotrophic water to by-pass the bog. The surface of the bog slopes gently toward north and north-northwest and is not actually domed.

¹ = *D. fluitans* v. *falcatum*.

The edge of the bog is covered by low black spruce forest with a rather dense undergrowth consisting mainly of *Chamaedaphne calyculata* and *Ledum groenlandicum*. There are no palsas, hollows, or pools in the marginal wood, which is better drained than the centre. In the central area are palsas from about one to 2.6 m in height and from 10 to 30 m across. Although the surface of the palsas consists of highly humified *Sphagnum* peat, live *Sphagnum* is never present on them. Most of the surface is covered by light-coloured lichens, among them *Cetraria nivalis*, a plant characteristic of wind-swept places with deficient snow cover in winter. On the north or northwest facing sides of the palsas occur small areas of brown peat which have been denuded by wind and rain erosion. The three principal plant communities of the palsas are recorded in Table 4 (Nos. 4-6). Some cryptogams of specialized edaphic requirements were found in the shady, cool, and moist habitat of deep fissures, among them the bryophytes *Dicranella cerviculata*, *Tetraphis* sp. (either *pellucida* or *geniculata*), and *Lepidozia reptans*, and the lichen *Coriscium viride*. Besides these, *Pohlia nutans*, *Polytrichum affine* (= *strictum*), *Cladonia deformis*, and a *Pertusaria* were found in the cracks but were not restricted to them.

Between the palsas there are ordinary, low hummocks built up by *Sphagnum fuscum* and usually dominated by the same species. On June 28 and 30 these hummocks were still frozen 3 dm below the surface and about 1.5 dm below the level of the standing water, above which the hummocks protruded; the frozen layer was less than 3 dm thick and would disappear in late summer.

The rest of the area between the palsas is chiefly covered by three types of wet bog vegetation or "bog hollow vegetation". Each of the three types covers about the same area as do the *Sphagnum fuscum* hummocks. One is found on rather firm peat and is dominated largely by the tussock plants of *Eriophorum spissum* and *Trichophorum caespitosum* var. *austriacum*, but also by *Carex limosa*; the incomplete bottom layer is composed of *Sphagnum balticum*, *rubellum*, *tenellum*, and other species. A different *Carex limosa* community grows on a softer substratum formed by a thick carpet of *Sphagnum Lindbergii*, *balticum*, *tenellum*, and *Dusenii*. The third type of vegetation is very scanty and occupies mud-bottoms with occasional sphagna and dark-coloured hepatics, at the time of our visit submerged in about one dm of water. Comparatively small areas are occupied by permanent pools of varying depth down to about one metre, along the edge of which were found occasional shoots of *Eriophorum russeolum* or *Carex limosa*. In the Hudson Bay lowland the latter species has a wider edaphic range than in Fennoscandian bogs, where it is mainly confined to soft *Sphagnum* carpets, mud-bottoms, and the edges of pools. At Hawley Lake *Carex limosa* is dominant also on firm peat and even within the *Sphagnum fuscum* hummocks. In most other respects, the differentiation of the vegetation corresponds closely to that of Fennoscandian bogs, where the corresponding communities are often regarded as stages in a cyclic micro-succession. However, the trends of succession may be more irregular, and the stages may be semi-stable for long periods. There is no final stage in the development of bog vegetation which can be regarded as "climax". As shown below, succession goes on, at least in some of the areas between the palsas, quite independently of the formation or collapse of individual palsas.



A. A 9-foot-high palsa in the western bog. A bog-pool in the foreground.



B. Side of the same palsa. Note the windblown black spruce, worn one-sided in winter by prevailing northwesterly winds (Sjörs, in "ARCTIC", 1959).

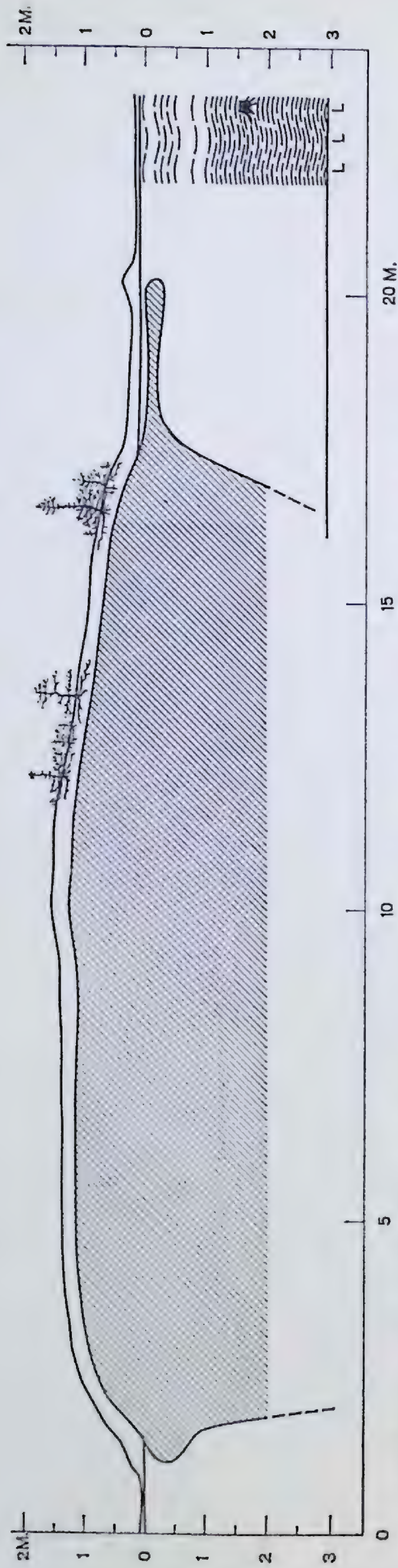
A SECTION OF A PALSA

A complete excavation of a palsa has probably never been made, but Lundqvist (1951), with a small party and with simple tools, was able to cut 2 m into a Swedish palsa and to show that the deeper parts (from 90 cm downward) consisted of laminated, frozen peat alternating with layers of pure ice somewhat thicker than the peat layers, the lamination conforming throughout to the convex surface of the palsa. We had neither the time nor the tools for such an excavation, which, moreover, would have been useless because the surrounding water could not be drained off. The easiest and perhaps most satisfactory method of "excavation" would have been to open the palsa by the aid of explosives, and then to work quickly before the deeper parts of the hole became flooded.

In place of excavation, a section through the unfrozen parts of a moderately-sized palsa surrounded by wet bog was dug or probed with a peat-borer, and carefully measured. As might be expected, this showed that the upper surface of the frozen body conformed almost exactly to the surface. A more important result was that the underground portion of the palsa was found to slope inward at an angle of about 60 degrees. Unfortunately it was impossible to probe at an oblique angle beyond a depth of 2 m below the ground-water level. It seems, however, almost certain that the frozen core of the palsa extended down into the soft clayey mineral soil reached at a depth of ca. 3 m between the palsas (*See Text Fig. 2*).

In the Hawley Lake region, the active frost layer is thin in places of normal snow cover and thaws completely each summer. Below this active frost layer the soil temperature remains above freezing throughout the year. At the time when palsa formation began, some of the larger bog hummocks probably were high enough to be only thinly covered by snow in winter. This likely was the case in open areas, such as the central parts of an almost treeless bog surface, from which the snow would blow away. A thin snow cover would cause the hummocks to lose heat more rapidly during the winter months than would the more deeply covered bog surface, so that the annual heat balance would be slightly negative, causing permafrost to persist within the hummock and gradually penetrate deeper into the peat. In summer the blanket of dry peat that covered the hummock would provide excellent insulation, while the light coloured lichen cover would absorb comparatively little radiation. These conditions would tend to make the annual heat balance still more negative. As the permafrost penetrated deeper, the surface of the hummock would rise, but only about 10 per cent of the depth of freezing. This was not sufficient to transform the hummock into a real palsa but would help the hummock to project still more through the winter snow.

Most authors on palsa formation agree up to this point, but different processes have been advocated for the succeeding stage during which the hummock grew to a palsa. Lundqvist (1951) was forced to reject all the earlier explanations proposed because they were contradictory to the above-mentioned ice lamination observed by him. According to Lundqvist, a slowly freezing wet colloidal soil like clay or peat will be cleft horizontally by pure ice layers. The ice crystals attract water by suction force when growing. To replace this water, moisture will be drawn into the growing palsa from below, and ultimately from outside. The sheets of pure ice add considerably to the body of the palsa, which will increase in height as long as new ice-sheets are formed under it.



TEXT FIGURE 2. Section through the body of a medium-sized palsa in a bog west of Hawley Lake, June 30, 1957. The frozen core is indicated by hatching. The roots of black spruce and tamarack are confined to the dry surface peat, which is mainly covered with whitish lichens. Note that the sides of the frozen core slope inward. It appears likely that the frozen core of the palsa extends below the peat into the underlying clay (indicated by *L*'s). The thin layer of frost in the peat beneath cushions of *Sphagnum fuscum* on the right is seasonal only. The *Sphagnum* peat surrounding the palsa is very soft near the surface; its lower strata are dense and highly humified and contain spruce wood. The profile of this peat was unfrozen, continuous, and undisturbed, down to the clay on which the bog rests. The bog is sloping slightly, so that the water-level on the right side of the palsa is 8 cm above that on the left. No vertical exaggeration (H. Sjörs, in "ARCTIC," Vol. 12, No. 1, fig. 13).

To explain the lamination further, the following hypothesis is now advanced. Each ice layer is formed as the freezing penetrates deeper at a very slow rate. At this rate, ice crystals are able to grow no faster than the speed at which the water solidified in the crystals can be replaced from below or from the surroundings through capillary movement or dehydration of peat or clay colloids. But if, for a period, freezing is faster than water replacement, a basal sheet of the peat or clay itself will also freeze. Later, formation of a pure ice layer will start again below the latter, but now at a somewhat slower rate, owing to increased thermal insulation. The result will be that the deeper the freezing penetrates, the slower the frozen body will grow, and the more the total frozen body will consist of pure ice-sheets. In a region where permafrost (at least near the soil surface) is limited to palsas, a small flow of heat will be conducted toward the palsa from below and from the unfrozen environment; ultimately a thermal equilibrium will be reached. In a true permafrost area, on the other hand, the process would be expected to go on almost indefinitely, provided enough water is available. Only if water in the liquid state is supplied, will the freezing lead to the formation of huge pingos (Porsild, 1938).

No peat is formed in the mature palsa. On the contrary, its summit layer is subject to shrinkage through biological oxidation and, locally, to erosion. Assuming that the uppermost layer of peat represented the contracted remains from the period at which the palsa was formed (with additions of more recent pollen), Lundqvist (1951) determined its probable age, by pollen analysis, to 3,000 years (or less). As the profile of this particular palsa did not show signs of erosion, it could scarcely have been much younger.

Eroded palsas are not so frequent at Hawley Lake as in the Swedish palsa areas; some nevertheless did show signs of erosion (see Plates IIIA and VA), a few even to a considerable degree. Once erosion starts, the growth of lichens, mosses like *Polytrichum affine* (= *strictum*), *Pohlia nutans*, and *Dicranum elongatum*, or of hepatics, is unable to check it. As a result of prolonged erosion, the summer thaw penetrates deeper, and slowly the palsa collapses. The heat-reflecting lichen cover disappears, and this, together with the deeper snow cover in winter, will reverse the heat balance and lead to complete disintegration by melting from all directions. Because the bulk of the palsa consisted of pure ice, a depression will eventually form. The total collapse of palsas is evidently rare at Hawley Lake. In the Swedish palsa areas, the early stages of collapse are frequent, and especially characteristic is the formation of a moat-like depression surrounding the palsa. This has been explained in different ways; presumably it may be formed by lateral melting started as a result of improving climate, which leads to an increasing flow of heat from the surroundings.

Palsas influence the water-balance of a bog by several effects, of which two continue to be active. The run-off from the palsas adds to the water supply in the areas surrounding them. Palsas may also act as dams impeding the run-off from the bog in which they are located. The combined effects may render the parts of the bog that remain unfrozen somewhat wetter than they would otherwise have been. At any rate, evidence of progressively increasing wetness was found in the peat profile obtained; this increasing wetness could perhaps be ascribed also to major climatic changes following the post-glacial warm period that probably preceded palsa formation.



A. A bog pool (collapsed palsa?) surrounded by palsas, one of which is strongly eroded.



B. Palsa with scattered black spruce in lichen mat. The western bog.

A section through unfrozen peat between two palsas was obtained with the peat-borer, beginning close to water-level, in a carpet of *Sphagnum Lindbergii*. The weakly humified *S. Lindbergii* peat extended down to 18 cm. From 18 to 125 cm a more humified *Sphagnum* peat was found, with medium humified *S. fuscum* peat between 65 and 95 cm. Below 125 cm the peat was strongly humified and firm, and remains of wood, mainly small twigs, were found in all samples. This peat was formed in a wooded bog, developed gradually from swampy woodland. The latter seems to have formed directly on the bluish, presumably marine clay (found at a depth of 294 cm), soon after the land emerged from the sea. No deposits were found suggesting that a tidal marsh, a wet fen, or a lake preceded the early forest. The site in this case is on a low and flat but slightly sloping watershed (p. 22), but it seems likely that much of the present extensive peatland area of the lowland was formed by similar paludification of forested land.

The peat samples obtained were given to Dr. Jaan Terasmae of the Geological Survey of Canada for micro-analysis and for possible C^{14} -dating of the bottom peat sample.

The position of the bog is $84^{\circ} 39' W.$, $54^{\circ} 34' N.$ Unfortunately only a rough estimate can be given of the elevation of the site. It is on the western plateau, which lies about 100 feet above Hawley Lake, which, again, is a few feet lower than Sutton Lake. The elevation given for the latter on National Topographical map sheet 43 N.W. of 290 feet undoubtedly is an approximation obtained by aneroid readings. The higher hill-tops of the Sutton Ridge (by Hawley's estimate roughly 600 feet above sea-level) were washed by wave action when they emerged from the sea, probably not long after the retreat of the ice.

It seems likely that, on the plateaux only, some of the oldest peatland has developed directly from tidal marshes. The peatland area may have increased greatly by the paludification of the earliest forest cover, notably woodland of an originally moist or swampy type. Along small streams, the action of beaver may have contributed to this. It does not seem likely that any considerable area of peatland was formed by the filling-in of lakes. The present coastal zone (Coombs, 1954, p. 12) is poorer in lakes than is the interior. It may thus be possible that the numerous shallow, roundish lakes of the interior were formed or at least much enlarged in comparatively recent time by wave erosion. Their regular, often roundish outline and often steep, slumping shorelines on the windward side are strongly suggestive of wave erosion, perhaps increased by repeated beaver damming.

Thus, upbuilding and degrading go on hand in hand in the peatland. The balance between divergent trends of succession leads locally to development of more or less mosaic patterns. It would be premature to attempt to formulate general principles designed to cover the dynamics of peatlands in the Hudson Bay lowland before the manifold ecological influences on the peatlands are better known. A great many factors in both the past and the present are at work; among others: climate, relief, water supply and drainage, chemical character of water, and influence of flora, fauna, and even fire.

The idea of a climax—not only the orthodox monoclimax, but even the polyclimax modification—seems unacceptable to students of peatland dynamic ecology. It is inconsistent with many observations on the development of northern woodlands and other kinds of vegetation as well.

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NOTES ON PLANT OCCURRENCE ALONG LOWER LIARD RIVER, NORTHWEST TERRITORIES

By W.W. JEFFREY¹

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Vascular plants.....	86
Literature cited.....	115
Illustrations.....(throughout text)	

ABSTRACT

The paper deals with a plant collection made in the lower Liard River area during June to September, 1959. The collection totalled 354 taxa, consisting of 34 lichens, 41 bryophytes, and 279 vascular plants. Twenty-nine taxa were believed to be new to the flora of the Mackenzie District.

Theme of the paper is plant occurrence. Brief attention is given to the physiography of the study area, which is segregated into four topographic divisions: (1) Mackenzie Mountains, (2) Mackenzie Lowlands, (3) older floodplains and terraces, and (4) recent floodplains. Their vegetation is subdivided into a total of 24 vegetation types, of which 13 are forests and six are brûlé and shrub types.

Plants of each vegetation type are listed following their segregation into six categories, of which one is corticolates and the remainder are layers of the vegetation. Wherever possible, the plants in each category are listed as primary, secondary, or occasional species. Following the description of the vegetation types, an annotated list considers each entity and its occurrence on the study area.

¹ Research Officer (Forestry), Forest Research Branch, Canada Department of Forestry, Calgary, Alta.

INTRODUCTION

The lower Liard River area, lying in the southwestern section of the Mackenzie District, Northwest Territories, has been given little botanical or ecological study in the past. Raup (1947) reported on studies and collections made around the Liard-Mackenzie confluence and at Brintnell Lake in the Mackenzie Mountains near the headwaters of the South Nahanni River. This paper is the most recently published summary of knowledge on the botany of southwestern Mackenzie District.

During 1959 the writer carried out an ecological study along that part of the Liard River lying between the British Columbia - Northwest Territories boundary and the confluence of Liard and South Nahanni rivers, lat. 60° N. to 61° N. approximately. The objective was to collect information on the forests of the area, their composition and structure, the type of land supporting them, the growth attained, and the composition of their lesser vegetation. As part of this work a plant collection was made, largely of forest species but also including plants of sandbars, shrub associations, road clearings, and the alpine tundra of the easternmost range of the Mackenzie Mountains. The collection comprised 354 taxa, consisting of 34 lichens, 41 bryophytes, and 279 vascular plants. Of these, one lichen, three bryophytes, and 25 vascular plants are believed to represent additions to the flora of the Mackenzie District.

The purpose of the writer's field work along the lower Liard was the collection of ecological data dealing with the forests of the area. The collection reflects this specialization of interest, being heavily weighted toward the taxa of the accessible forested lowlands. Though an attempt was made, wherever convenient, to collect as many species as possible, coincident with other duties, omissions of common but critical species are apparent. This would not have been the case had the collector been a professional taxonomist with the gathering of botanical material the main *raison d'être* for his field work.

The theme of the present paper is plant occurrence. Its purpose is to summarize the botanical information accumulated by the writer in the course of the study. No consideration has been given to the ecology of the vegetation types, and the environment has been discussed only briefly to provide a reasonable supplement to the botanical information. These other questions will be examined in a future paper dealing with the ecology of the forests in the area.

ACKNOWLEDGMENTS

Many individuals kindly extended help and hospitality during the course of the field work. To all of them, particularly Mr. Gus Kraus of South Nahanni, N.W.T., the writer wishes to extend his thanks. Mr. Edward Diamond of Fort Liard, N.W.T., was the writer's guide during the summer and gave much valuable assistance.

Grateful acknowledgment is made to the following: Dr. A. E. Porsild, Chief Botanist of the National Museum of Canada, who not only gave help and encouragement but identified most of the vascular plants and critically read and discussed parts of the manuscript; Dr. H. Crum, National Museum of Canada, who identified and annotated the majority of the bryophytes



FIGURE 1. Map of lower Liard River area (Scale: 1 inch = 12 mi. approx.).

and lichens; Dr. A. W. Herre (retired, of Santa Cruz, California), who identified the *Usnea* specimens; Dr. I. M. Lamb, Harvard University, who identified the specimens of *Stereocaulon*, and Dr. J. W. Thomson, University of Wisconsin, who identified several critical lichen specimens.

Thanks are also due to the Water Resources Branch, Department of Northern Affairs and National Resources, Vancouver, for information on the Liard River and to the Laboratory of Forest Biology, Department of Agriculture, Calgary, for photographic assistance.

PREVIOUS INVESTIGATION

The lower Liard River area has received little study in the past. R. G. McConnell of the Canadian Geological Survey surveyed Liard River to its junction with the Mackenzie in 1887 (McConnell, 1891). Though from then on increasing survey activity was the rule for the northern territories, lower Liard River apparently was given no further study until 1922 when Hume (1923) carried out a reconnaissance of part of the river. Since then, the geology of the area has been studied by Hage (1945) and its soils by Leahey (1944).

So far as is known, only two small plant collections have been made in the area, the first by C. L. Crickmay in 1922, the second by F. S. Nowosad in 1944. The first of these collections is in the National Herbarium of Canada; the second is in the Herbarium of the Department of Agriculture, Canada. In addition, a small collection was made at Trout Lake, east of Liard River, by C. O. Hage in 1944. This collection is believed to be in the Arnold Arboretum of Harvard University.

Of botanical work related to the area, though not actually carried out within its boundaries, there is a greater volume. H. M. Raup's work on the Peace and upper Liard areas and in Wood Buffalo Park is presented in his numerous papers, those of 1934, 1935, 1936, 1946, and 1947 being probably the most important. A. E. Porsild's work in the southeastern Yukon is contained in his paper of 1951. Other related work was reported by Porsild (1943, 1945).

BOUNDARIES OF STUDY

The area examined is that immediately adjacent to the water route of the Liard River from the British Columbia - Northwest Territories boundary in the south to the confluence of the Liard and South Nahanni rivers in the north. It thus generally represents a narrow strip of land bordering the river. Penetration of the country away from the river generally did not exceed one to two miles, with the exception of several extended trips to both east and west.

Greatest penetration was effected in the Mackenzie Lowlands where, immediately south of the confluence of Liard and Petitot (Black)¹ rivers, a distance of 17 to 18 miles was covered in a south-southeasterly direction. This was the only noteworthy excursion into the country east of the river. West of the river one trip was made into the Liard Range, where a distance of 13 to 15 miles north-northwest of Fort Liard was traversed to reach an

¹Petitot River is still known locally as "Black River," the original name, apparently derived from its peat-stained water coming from the Mackenzie Lowlands.

elevation of approximately 3,800 feet. From this point the west slopes of the Liard Range were descended to reach the south end of Fisherman Lake, from which point the route bore southeasterly back to Fort Liard. In the Flett Creek area, 35 miles north of Fort Liard, a distance of 8 miles was traversed west along the Flett Creek valley.

The work in the Mackenzie Lowlands was done on July 20 to 23, that in the Liard Range on July 26 to 31, and that at Flett Creek on August 11 and 12. These trips were made on foot, back-packing, with a pack-dog to carry additional supplies.

One tributary stream, Kotaneelee River, was navigated for 6 miles on July 7. On August 22, Nahanni Butte was ascended to its summit, elevation approximately 4,300 feet. During the remainder of the field-work period, June 24 to September 7, the writer worked by canoe on Liard River and concentrated his work in the forests of floodplains and terraces.

THE ENVIRONMENT

A study of vegetation is incomplete without some consideration of the environment under which it has developed, since this, along with history (fire has in this case been especially important), is a major influence upon vegetation. In this paper the environment is treated under two main headings, "climate" and "land." Though it is not meant to imply that these together represent the whole environment, their consideration helps to form a reasonably adequate appraisal of the environment.

CLIMATE

The study area varied between 600 and 4,300 feet above sea-level. This inevitably implies a considerable variation in climatic conditions within the area. No meteorological station is located within the boundaries of the study, and climatic data can only be taken from the stations nearest the area. These are Fort Nelson, B.C., which lies 100 miles southeast of the southern boundary of the study area, and Fort Simpson, N.W.T., 90 miles east-northeast of the area's northern limit.

Thus the values for temperature and precipitation which follow were gathered at two stations lying respectively at lat. $1^{\circ} 50' S.$ and $0^{\circ} 50' N.$ of the study area, the study area itself extending just over one degree latitude. In addition to the distances involved, it should be borne in mind that Fort Nelson and Fort Simpson both lie much farther east of the nearest range of mountains than does the study area.

The meteorological station at Fort Nelson, B.C., is located at $58^{\circ} 50' N.$, $122^{\circ} 35' W.$ at an elevation of 1,230 feet. Fort Simpson, N.W.T., lies at $61^{\circ} 52' N.$, $121^{\circ} 13' W.$ at 572 feet elevation.

Temperature data for these stations are given in Table 1.

Precipitation data are given in Table 2.

There are climatic differences between the two stations, the annual means at Fort Simpson being $5^{\circ} F.$ lower than those at Fort Nelson. It will be noted, however, that the mean temperatures for June, July, and August, the most active months for growth, are similar at the two stations. The

TABLE 1. TEMPERATURE* AT FORT NELSON, B.C., AND FORT SIMPSON, N.W.T.

	Years Obs.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An- nual
AV. DAILY MAX. TEMP. (°F.)														
Fort Nelson.....	13	2	8	30	47	62	70	74	71	61	44	15	1	40
Fort Simpson.....	27	-7	0	16	37	55	69	75	69	56	38	13	-3	35
AV. DAILY MIN. TEMP. (°F.)														
Fort Nelson.....	13	-14	-11	6	23	38	47	50	46	38	26	2	-12	20
Fort Simpson.....	27	-23	-19	-7	14	34	46	50	46	37	24	-1	-19	15
AV. DAILY MEAN TEMP. (°F.)														
Fort Nelson.....	13	-6	-1	18	35	50	58	62	58	50	35	9	-6	30
Fort Simpson.....	27	-15	-9	4	25	45	57	62	58	47	31	6	-11	25

TABLE 2. PRECIPITATION* AT FORT NELSON, B.C., AND FORT SIMPSON, N.W.T.

	Years Obs.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An- nual
AV. RAINFALL (in.)														
Fort Nelson.....	13	T	0.02	0.01	0.29	1.34	2.53	2.36	1.52	1.19	0.42	0.01	T	9.69
Fort Simpson.....	28	0.00	0.00	T	0.13	0.90	1.39	1.94	1.63	1.29	0.32	T	0.01	7.61
AV. SNOWFALL (in.)														
Fort Nelson.....	13	8.6	11.4	7.0	5.5	1.0	0.0	0.0	T	1.3	6.1	13.6	12.3	66.8
Fort Simpson.....	28	7.6	6.2	4.4	3.7	1.6	0.0	0.0	T	0.4	4.5	9.1	7.7	45.2
TOTAL PRECIPITA- TION (in.)														
Fort Nelson.....	13	0.86	1.19	0.71	0.84	1.44	2.53	2.36	1.52	1.32	1.03	1.37	1.23	16.37
Fort Simpson.....	28	0.76	0.62	0.44	0.50	1.06	1.39	1.94	1.63	1.33	0.77	0.91	0.78	12.13

*The values above were taken from "Climatic Summaries for Selected Meteorological Stations," Meteorology Division, Department of Transport, Canada.

mean temperatures in May and September, however, are lower at Fort Simpson than at Fort Nelson. Total annual precipitation is greater at Fort Nelson than at Fort Simpson, as is the mean rainfall. June is the wettest month at Fort Nelson, whereas July is wettest at Fort Simpson. Mean rainfall during the period June to August inclusive is 6.41 inches at Fort Nelson and 4.96 inches at Fort Simpson.

Rowe (1959: 65) discussed data for the growing season at Fort Simpson. The average date when the mean temperature reached 42°F. is May 10. The mean growing season is 138 days, mean temperature during the growing season being 55°F., and mean rainfall during the growing season being 6.8 inches.

No extensive data are available dealing with the effect of proximity to the Mackenzie Mountains or of increased elevation. Raup (1947: 32-34) compared the climates of Fort Simpson and Brintnell Lake at 2,600 feet elevation. His observations indicated the climate at higher elevations to be appreciably colder and wetter than in the river valleys.

In general terms, the climate of the study area is northern continental, characterized by short, dry growing seasons and long, cold winters.

THE LAND

Geography. Liard River is a broad, relatively swift-flowing stream which rises in the Yukon Territory to flow southeasterly into northern British Columbia, where at its junction with Racing River it turns northerly to enter the Northwest Territories at latitude 60° North. At the British Columbia-Northwest Territories boundary it flows almost due north, soon veering easterly to its confluence with the Muskeg River about 28 air miles northeast of the boundary. From this point to Flett Creek it runs in a straight course north and slightly west for a distance of approximately 30 miles. From Flett Creek the river continues its course as a winding, almost sluggish stream to its confluence with South Nahanni River, a distance of about 25 miles by air and about 50 miles by water. The total water-route distance from the boundary to the confluence is about 110 miles, the total air distance about 75 miles.

The meander belt of Liard River extends below the mouth of South Nahanni River for about 30 miles, after which it maintains a fairly straight course east and north to its junction with Mackenzie River at Fort Simpson, N.W.T.

At Fort Liard, Liard River is about 1,500 feet wide; its narrowest point in the area is 700 feet. Average dates of "freeze-up" and "break-up" are November 15 and May 10 respectively. The mean difference in water-level between low and high water is about 17 feet (Water Resources Branch, 1959).

PLATE I



General view of Liard River and Liard Range, about 25 miles below Fort Liard.

Main tributary streams entering the Liard are Petitot, Muskeg, and Nétla rivers from the east, and Kotaneelee River, Flett Creek, and Blue Bill Creek from the west. Distances from the south boundary by air are as follows: Petitot River, 20 miles; Muskeg River, 28 miles; Nétla River, 65 miles; Kotaneelee River, 12 miles; Flett Creek, 50 miles; and Blue Bill Creek, 60 miles.

Liard River roughly represents the boundary between the two main topographical divisions of the area, the eastern range of the Mackenzie Mountains west of the river, and the Mackenzie Lowlands to the east (Hage, 1945: 1). The river skirts the southern end of the mountains near the British Columbia-Northwest Territories boundary and flows approximately parallel to them to its junction with South Nahanni River.

The eastern range of the Mackenzie Mountains, known as the Liard Range, begins opposite Fort Liard, with summits between 3,000 and 4,000 feet in elevation. South Nahanni River cuts through this range about 20 miles above its mouth. Nahanni Butte, 4,300 feet in height, just north of the Liard-South Nahanni confluence, is the southern end of Nahanni Range which, with the exception of Nahanni Butte, lies north of the study area.

Geology. Owing to the predominance of glacial, fluvio-glacial, and alluvial post-Pleistocene deposits, structural geology is not believed to influence greatly the vegetation on much of the area. Rock outcrops in the Mackenzie Lowlands are rare (Hage, 1945: 26).

Liard and Nahanni ranges are bounded on the east by west-dipping thrust faults. Liard Range is formed of sandstones, shales, cherts, and limestones of Carboniferous age. Nahanni Butte is formed of Middle Devonian limestones and dolomitic limestones overlying Silurian siliceous limestones and dolomites (Hage, 1945: 5).

On Muskeg and Petitot rivers there are exposures of sandstone, shale, and sandy shale beds of lower Cretaceous age, whereas upper Cretaceous sandstones, pebble conglomerates, and shales are present as outcrops along Liard River south of the Liard-Kotaneelee confluence.

Present knowledge of the stratigraphy of the area was summarized by Hage (1945).

Topography. Liard River, flowing at an elevation of 600 to 700 feet in the study area, undergoes a notable change which profoundly affects the topography of its valley. From the British Columbia-Northwest Territories boundary to Flett Creek, the Liard is a braided stream with a relatively straight course, but from Flett Creek to the Liard-South Nahanni confluence the river meanders considerably. In its straight course in the southern part of the area the river-banks are fairly steep. On the east they rise 300 to 500 feet above the river and may, as they do opposite Kotaneelee River, extend 900 feet above the present channel. From the top of these banks the land slopes gradually upward into the plains of the Mackenzie Lowlands, where elevations of 1,500 to 1,800 feet are generally reached 15 to 20 miles east of the river. West of the river, in the southern part of the area, the land rises more gradually, though fairly steep banks are present in places close to the river. An increase in elevation of 200 to 300 feet per mile is common.

In the northern part of the area, the seasonal flooding associated with meander zones has resulted in the formation of a broad floodplain extending in places for as much as 8 to 10 miles, on either side of the river. The differing character of the valley in the two zones is shown by Figures 3 and 4. Figure 3 shows the valley just north of the Muskeg-Liard confluence, Figure 4 the profile near the mouth of the Nétla River.

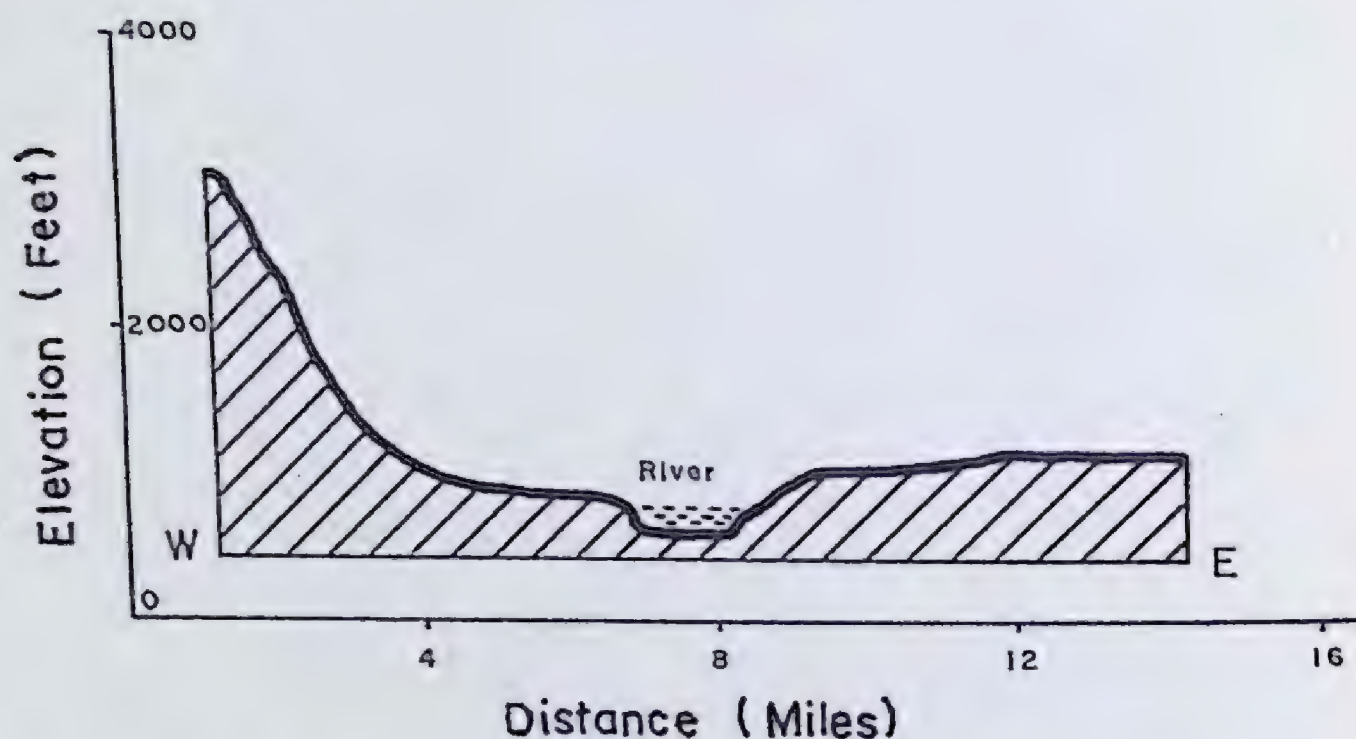


FIGURE 2. Section through Liard River Valley about lat. $60^{\circ} 20' N$. (Note difference between vertical and horizontal scale.)

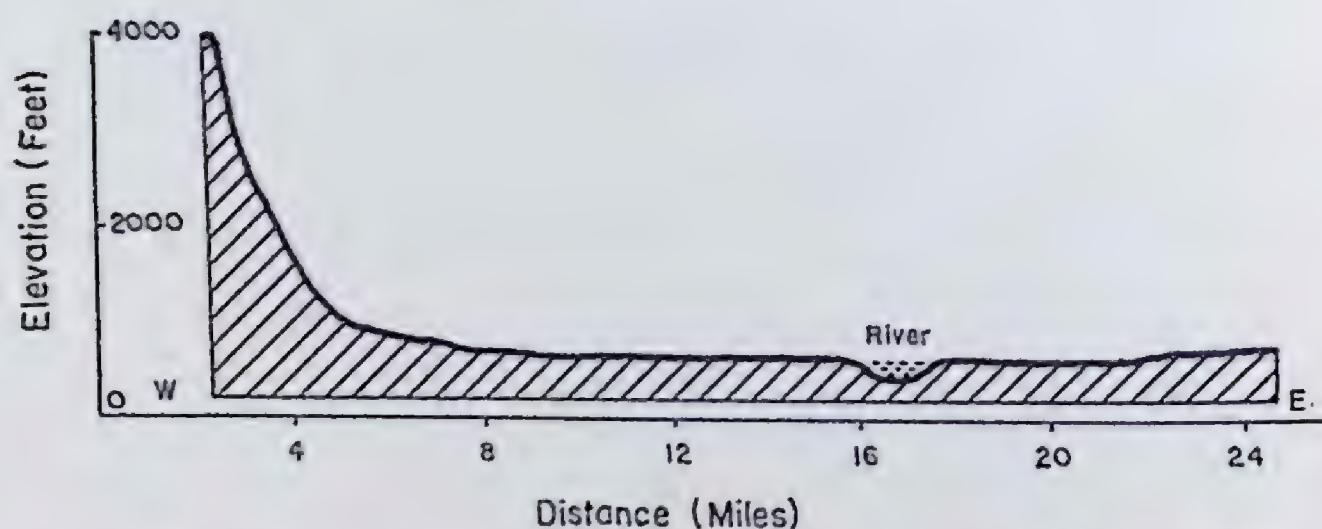


FIGURE 3. Section through Liard River Valley about lat. $60^{\circ} 56' N$. (Note difference between vertical and horizontal scale.)

In the mountains all degrees of slope exist, though steep slopes are by far the most prevalent. In the Mackenzie Lowlands, on the other hand, slopes are gradual, and the land may be termed either rolling or undulating.

Between river level at 600 to 700 feet and the beginning of both the Mackenzie Mountain and Mackenzie Lowland zones proper, at 1,500 to 1,600 feet, topography is extremely variable. This elevational zone has been subjected to alluvial soil deposition, and its soils are more similar to those of older parts of the floodplains than to the soils of either the Mackenzie

Mountains or the Mackenzie Lowlands. Topography ranges from steep terrace slopes to the gently undulating point-bar deposits typical of floodplain deposition.

In this manner the study area may be divided into three main topographic divisions:

- (1) *Mackenzie Mountains*, lying west of Liard River, elevation 1,600 to 3,800 feet in the Liard Range and up to 4,300 feet on Nahanni Butte, characterized by steep slopes.
- (2) *Mackenzie Lowlands*, lying east of Liard River, elevation 1,600 to 1,700 feet in the area examined, characterized by rolling topography and relatively gentle slopes.
- (3) *Floodplains and terraces*, lying adjacent to Liard River on both east and west, elevation 600 to 1,600 feet, topography variable, gently undulating in the floodplains, steep to gentle slopes and flats in the terraces.

These topographic zones are the primary basis of subdivision into vegetation types. Soils, however, will be seen to necessitate consideration of further subdivision of the floodplain and terrace topographic division.

Geomorphology and Soil. On the steep topography of the Mackenzie Mountains the soils examined were usually very shallow, save for occasional deeper pockets formed by entrapment of colluvial materials. These mountain soils have been formed either from glacial deposits or, much less frequently, by weathering of the parent rock. In texture they tend to be relatively light, varying from sandy-loam to loam. Surface pH values vary between 4.5 and 5.5. Little profile development was noted, and depth to bed-rock was seldom greater than 20 inches, the average being around 15 inches. Stones, from rounded small pebbles to large angular fragments, are common in the profile. Parent material varies from sandstone or conglomerate bed-rock to unsorted till. In the occasional bed-rock outcrops, vegetation tends to be concentrated in the soil accumulations of rock crevices.

Upland soils in the Mackenzie Lowlands are believed to be glacial or fluvio-glacial in origin. Rough sorting of materials is evident throughout the profile, probably as the result of glacial meltwater action. These soils are much deeper than those in the mountains and show a much greater variation in soil pH; surface values range from 4.5 to 8.0. The Mackenzie Lowland soils are stony, containing a considerable fraction of the small water-worked pebbles typical of fluvio-glacial soils. On drumlinoids of the Mackenzie Lowlands the soil consists of leached unsorted till of strongly acid surface pH. Soil texture varies between loamy sand and clay loam.

In addition to these upland soils, the Mackenzie Lowlands abound in hydromorphic soils of the lowmoor type (*sensu* Wilde, 1958). These organic soils generally belonged to the brown moss peat group. The depth of the organic layer varied between 11 and 30 inches but could not always be determined because of soil frost.

The floodplain and terrace zone is characterized by wholly or relatively stone-free soils resulting from alluvial deposition. These soils

occurred on a wide range of topography from steep slopes to gently undulating point-bars. The floodplain and terrace zone, on the basis of edaphic characteristics, has been subdivided into the *older floodplains and terraces* and the *recent floodplains*.

In the the older floodplains and terraces the soil is deep, reddish brown in colour, and stone-free, except on some of the steep terraces, where small rounded pebbles were occasionally found. The soil pH reaction varied from 4.0 to 8.0, both brown-wooded and podzolic soil types being represented. Texture was likewise variable, ranging from sand to clay, the most common surface texture being sandy loam to loam. Leaching is prevalent in these soils, some of which had profiles characteristic of the Grey-Wooded soil group.

The older floodplains contain small areas of hydromorphic soils. These are localized in wet depressions and belonged to the brown moss peat group. Depth of the organic layer is sometimes 30 to 40 inches.

The recent floodplains consist entirely of stone-free juvenile soils, grey in colour with no profile development. Texture varies between sand and clay loam, light textures being most prevalent. Soil pH is invariably high, 7.0 to 8.0. The recent floodplains demonstrate the typical point-bar depositional characteristics of fluvial deposits (Thornbury, 1954: 167-171). It is these juvenile and basic soils of the recent floodplains which made necessary the subdivision of the floodplain and terrace zone.

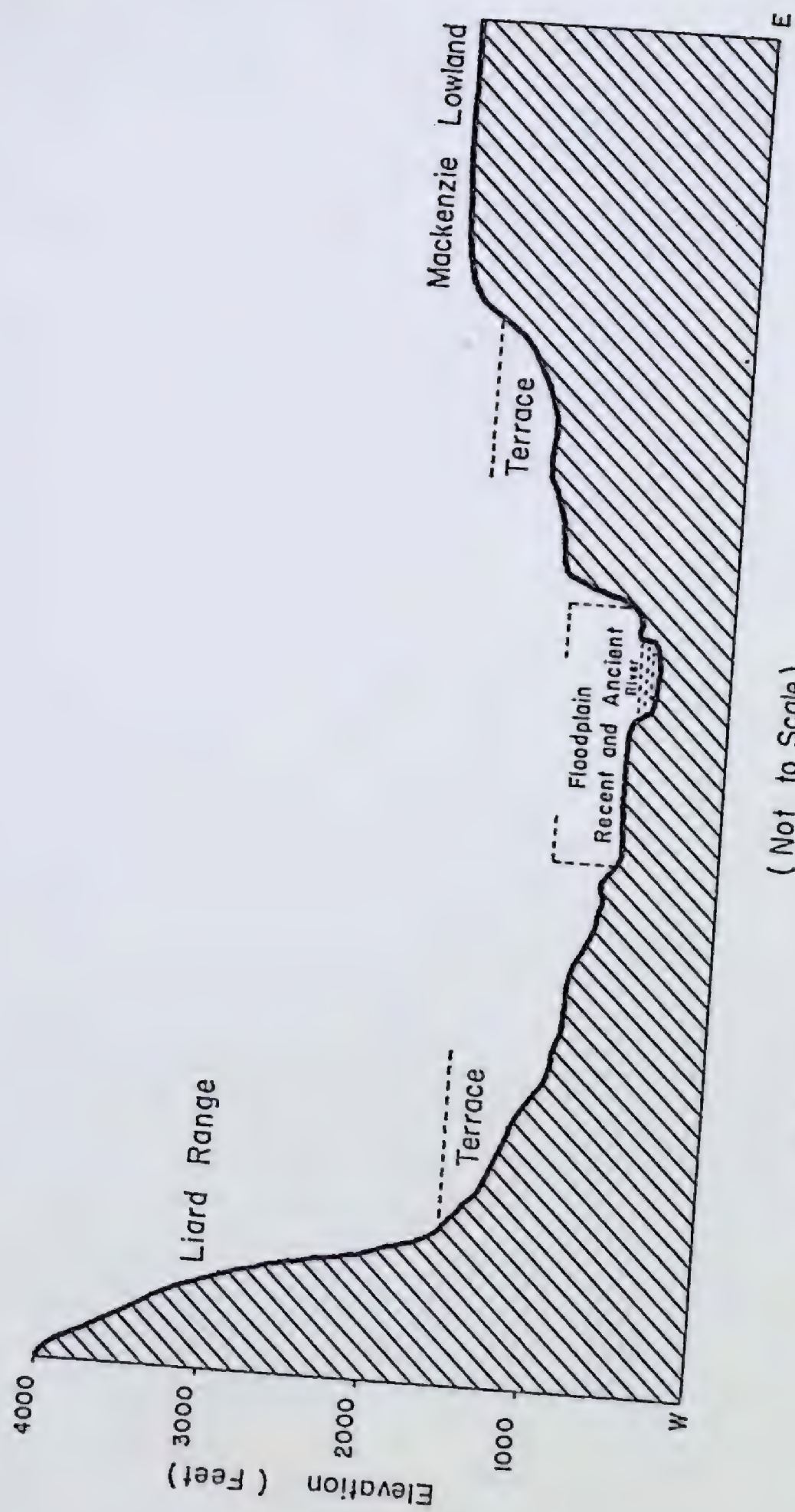
In the study area, soil frost was sporadic and did not appear to demonstrate any easily recognizable pattern in its occurrence.

THE VEGETATION

TOPOGRAPHIC DIVISIONS AND VEGETATION TYPES

The four topographic divisions outlined, i.e., (1) Mackenzie Mountains, (2) Mackenzie Lowlands, (3) older floodplains and terraces, (4) recent floodplains, serve as a useful framework for consideration of the vegetation. The use of this terminology for the four topographic divisions (landtypes) is not meant to imply that in the broad topographical sense these are of equal rank. The Mackenzie Mountains and Mackenzie Lowlands naturally have higher rank than the floodplain divisions. Perusal of Table 3, however, will show how heavily weighted was the writer's sample toward the floodplains, especially the forested parts. Under these circumstances considerations of rank have been ignored. Each division, largely on the basis of its present vegetative cover, is subdivided into a number of "major vegetation types" or "vegetation types." Because in some cases the vegetation types occupy widely varying topography and soils, they are, in general, broad groupings.

However, as mentioned in the introduction, the purpose of this paper is the summary of information on plant occurrence. A detailed consideration of vegetation-environment relationships is not intended.



(Not to Scale)

FIGURE 4. Diagrammatic representation of the topographic divisions.

LIST OF VEGETATION TYPES

In the present paper a total of 24 vegetation types will be considered. They are listed below.

I. MACKENZIE MOUNTAINS

- A. Alpine tundra
- B. Mixed forest at timberline
- C. *Abies lasiocarpa* forest
- D. Mixed coniferous forest
- E. *Pinus contorta* var. *latifolia*-lichen woodland
- F. Dry rocky slope forest

II. MACKENZIE LOWLANDS

- A. Mixedwood forest
- B. *Picea mariana* forest
- C. Brûlé*
- D. Depressional shrub

III. OLDER FLOODPLAINS AND TERRACES

- A. Mixedwood forest
- B. Mixed broadleaved forest
- C. *Picea mariana* forest
- D. Meadow
- E. Shrub, channel, and inundated areas
- F. Brûlé*
- G. Man-made clearings

IV. RECENT FLOODPLAINS

- A. Sandbars and river-banks
- B. Riparian shrub
- C. Depressional shrub
- D. *Populus balsamifera* forest
- E. *Picea glauca* forest
- F. Other forest vegetation types
- G. Brûlé*

It should be noted that certain vegetation types occur in more than one topographic division. The Mackenzie Lowlands and the older floodplains and terraces both support *Picea mariana* forest and mixedwood (*Picea glauca*-*Populus tremuloides*) forest. The Mackenzie Lowlands, the older floodplains and terraces, and the recent floodplains, all support shrub and brûlé vegetation types. These separations have been made on the basis of topographic, edaphic, and/or floristic differences between the vegetation types of one topographic division and those of another.

DESCRIPTION OF VEGETATION TYPES

The layered physiognomy of the vegetation is the basis for description. Five layers were recognized, namely, *tree layer*, *underwood layer*, *shrub layer*, *herb layer*, and *bryophyte and lichen layer*. Another category, that of *corticulates* (bark-growing epiphytes), has been added where appropriate. In some vegetation types, all five layers were present; in others, one or more might be absent. Intergradation of the shrub and herb layers also at times made it difficult to stratify the plant cover. In general, however, the layered physiognomy was well suited to description of the vegetation.

Within the layers, species have been assigned to one of three categories, namely, *primary*, *secondary*, or *occasional* species. A primary species is considered to be one which was present in 75 per cent or more of the stations of the appropriate vegetation type, and normally, in addition, was relatively abundant. Occasional species generally were never abundant in the pertinent layer, and, furthermore, occurred within that layer on less than 20 per cent of the stations examined. Secondary species are those that did not qualify as

*The term "brûlé" applies to areas burned-over within approximately 30 years prior to investigation, whose vegetation has not yet attained pole size.

either primary or occasional, i.e., present on between 20 and 75 per cent of the stations examined, regardless of abundance. Secondary species, however, seldom occupied a dominant position in the vegetation.

Some species were necessarily listed in more than one layer of a vegetation type. For instance, in the mixed broadleaved forest of the older floodplains and terraces, *Ribes triste* occurred as an occasional species of the shrub layer and as a secondary species of the herb layer. Similarly, the terms "shrub" and "herb," designating certain layers, are somewhat inexact. Though the components of these layers were predominantly that which their names would indicate, the practice was followed of placing each species where it actually occurred, rather than of placing all shrubs in the shrub layer and all herbs in the herb layer. In this way *Ribes triste* was often found in the herb layer, and *Pteritis nodulosa* was sometimes noted in the shrub layer.

The basis of assessment of species status was a series of 195 station records. Plant species were listed on each station by layers according to the Braun-Blanquet scale of cover-abundance. Distribution of these stations is given in Table 3.

TABLE 3. DISTRIBUTION OF STATIONS EXAMINED

Topographic Division	Vegetation Type				
	Forest	Shrub	Brûlé	Other	Total
Mackenzie Mountains.....	22	Nil	Nil	6	28
Mackenzie Lowlands.....	11	2	4	Nil	17
Older floodplains and terraces.....	70	2	10	2	84
Recent floodplains.....	47	13	2	4	66
Total.....	150	17	16	12	195*

*An additional five stations were examined in recent floodplains of tributary streams. These have not been included.

Sampling of the floodplain and terrace divisions was much more intensive than that of the Mackenzie Mountains and Mackenzie Lowlands. This was the result of two factors: the necessary concentration upon the most productive forest types and the difficulties of overland travel.

I. THE MACKENZIE MOUNTAINS

Exploration of this topographic division was limited to a very small portion of Liard Range and to Nahanni Butte which could be given only the most superficial attention. For example, on the lower slopes of Nahanni Butte a young fire-induced forest of *Pinus Banksiana* was seen by the writer at a time when, because of inclement weather and time limitations, description could not be undertaken. No further opportunity for examination arose, and as a result, this vegetation type does not appear in this paper.

In addition, a lodgepole pine forest, characterized by the presence of *Vaccinium caespitosum*, was noted on the west slope of the Liard Range at

an elevation of 3,500 to 3,700 feet. Only one station could be examined, its description being appended to the Timberline Forest vegetation type. Aerial examination has led the writer to believe that this represented yet another vegetation type.

Thus this study has done no more than offer a tantalizing glimpse of the Mackenzie Mountain vegetation, and full knowledge must await further exploration.

The Mackenzie Mountains in the study area lie between 1,600 and 4,300 feet elevation and are forested up to about 3,800 feet. They are characterized by steep topography and shallow acidic soils. Tree growth is poor. Species not previously recorded in the Mackenzie District and noted in this topographic division were *Usnea caucasica*, *Dicranum drummondii*, *Poa interior*, *Luzula multiflora* ssp. *frigida*, *Listera cordata*, *Sorbus scopulina*, *Oxytropis varians*, *Vaccinium caespitosum*, and *Vaccinium membranaceum*. Other noteworthy species included *Usnea lapponica*, *Lycopodium obscurum* var. *dendroideum*, *Pinus contorta* var. *latifolia*, *Arctophila fulva*, *Carex Williamsii*, *Juncus biglumis*, *Spiraea Beauverdiana*, *Gentiana prostrata*, *Arnica cordifolia*, and *Senecio triangularis*. Perhaps the most significant discovery was that of large areas occupied by *Pinus contorta* var. *latifolia* growing as a forest tree and descending to an elevation of 1,800 feet within 5 miles of Fort Liard.

The vegetation of the Mackenzie Mountains is characterized by a high representation of some families. Most of the lichens collected came from this zone, along with a high proportion of the *Polytrichaceae*, *Lycopodiaceae*, *Juncaceae*, *Ericaceae*, *Gentianaceae*, *Scrophulariaceae*, *Campanulaceae*, and *Compositae*.

Though the Liard Range and Nahanni Butte have been, for the sake of convenience, placed in the same topographic division, study of their vegetation showed noteworthy floristic distinctions between the two. For example, whereas the primary species of the tundra on Nahanni Butte were all noted in the Liard Range, other species were found which were not noted elsewhere. These included *Cystopteris fragilis*, *Lycopodium Selago*, *Poa interior*, *Gentiana arctophila*, *Gentiana prostrata*, *Campanula aurita*, *Antennaria densifolia*, and *Antennaria isolepis*. Similarly, numerous species noted in the Liard Range tundra were not found on Nahanni Butte. This floristic distinction extended also to the forests of the two ranges, such species as *Juniperus horizontalis*, *Pulsatilla Ludoviciana*, *Anemone parviflora*, *Symphoricarpos occidentalis*, and *Campanula rotundifolia* being noted only on Nahanni Butte. The reasons for this diversity may only be surmised at the present time. They might include exposure (the area examined on Nahanni Butte being largely south-facing), underlying bed-rock, or soil moisture. Because of the differences between the two areas their vegetation has been kept separate in the descriptions.

Vegetation types of the Mackenzie Mountains topographic division comprised alpine tundra, timberline forest, *Abies lasiocarpa* forest, mixed coniferous forest, *Pinus contorta* var. *latifolia*-lichen woodland, and dry rocky slope forest (see Figure 6).

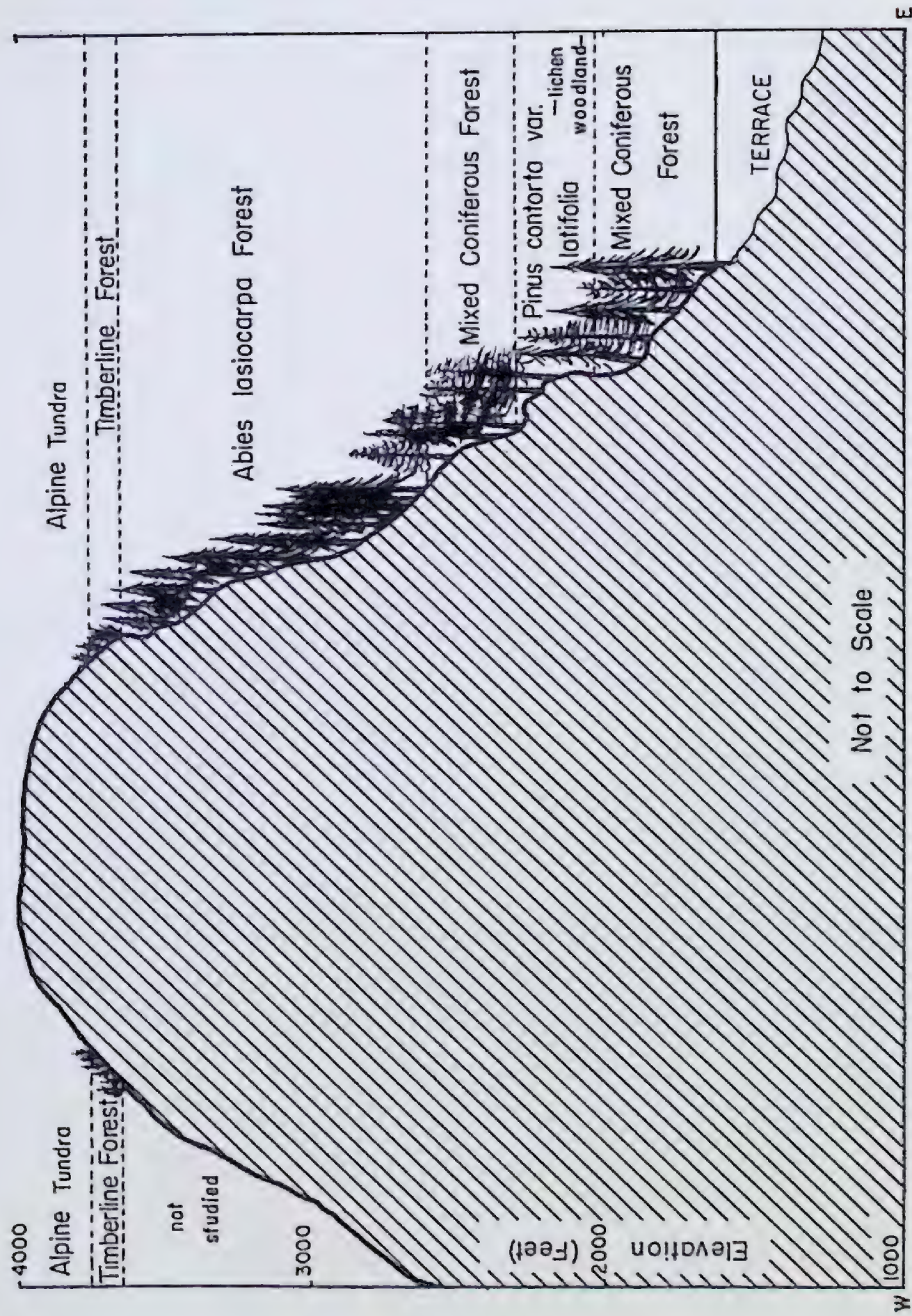


FIGURE 5. Diagrammatic representation of vegetation types in the Liard Range.

A. Alpine Tundra

Tundra examined lay between elevations of 3,800 and 4,300 feet. Composition of the vegetation was variable, and differentiation into layers and communities was difficult. Apparently minute differences in exposure caused noticeable changes in the vegetation.

Tundra on the summit of Nahanni Butte around 4,300 feet contained the following:

Vascular Plants. Less than one foot in height. Density, rather dense.

Primary Species

Carex scirpoidea, *Polygonum viviparum*, *Saxifraga tricuspidata*, *Potentilla fruticosa*, *Dryas integrifolia*, *Pyrola grandiflora*, *Rhododendron lapponicum*, *Vaccinium uliginosum*.

Secondary and Occasional Species

Cystopteris fragilis, *Lycopodium complanatum*, *Lycopodium Selago*, *Calamagrostis purpurascens*, *Trisetum spicatum* var. *Maidenii*, *Poa interior*, *Agropyron latiglume*, *Salix arbusculoides*, *Salix glauca* var. *Aliceae*, *Betula papyrifera* (shrub), *Cerastium Beeringianum*, *Silene acaulis* var. *subacaulescens*, *Aconitum delphinifolium*, *Anemone parviflora*, *Ledum decumbens*, *Gentiana arctophila*, *Gentiana prostrata*, *Pedicularis capitata*, *Campanula aurita*, *Antennaria densifolia*, *Antennaria isolepis*, *Arnica louiseana* ssp. *frigida*, *Senecio lugens*.

Bryophytes and Lichens. Density, over 75 per cent cover.

Cladonia macilenta fo. *styracella*, *Pertusaria* sp., *Cetraria cucullata*, *Cetraria islandica*, *Cetraria nivalis*, *Cetraria Tilesii*, *Alectoria nigricans*, *Alectoria ochroleuca*, *Ditrichum flexicaule*, *Ceratodon purpureus*, *Hypnum cupressiforme*, *Polytrichum juniperinum*.

On Nahanni Butte, in niches sheltered from the west, around 4,300 feet, the following additional species were noted:

Vascular Plants

Picea glauca, *Betula glandulosa*, *Arctostaphylos rubra*, *Arctostaphylos Uva-ursi*.

Bryophytes and Lichens

Dicranum fuscescens, *Aulacomnium turgidum*, *Rhytidium rugosum*, *Hylocomium splendens*.

Between 3,900 and 4,300 feet, *Juniperus communis* var. *montana*, *Zygadenus elegans*, *Astragalus alpinus*, and *Arnica louiseana* ssp. *frigida* were also noted.

In the Liard Range the tundra examined was around 3,800 feet elevation and showed considerable floristic differences from that of Nahanni Butte.

Vascular Plants. Less than one foot in height. Density variable, usually rather dense.

Primary Species

Salix glauca var. *Aliceae*, *Betula glandulosa*, *Dryas integrifolia*, *Oxytropis varians*, *Ledum decumbens*, *Rhododendron lapponicum*, *Arctostaphylos rubra*, *Vaccinium uliginosum*, *Vaccinium Vitis-Idaea* var. *minus*.

Secondary and Occasional Species

Picea glauca (shrub), *Abies lasiocarpa* (shrub), *Juniperus communis*, *Hierochloa alpina*, *Calamagrostis purpurascens*, *Trisetum spicatum*, *Poa glauca*, *Arctophila fulva*, *Festuca brachyphylla*, *Bromus Pumpellianus*, *Eriophorum brachyantherum*, *Carex capillaris*, *Carex Williamsii*, *Juncus biglumis*, *Juncus castaneus*, *Luzula multiflora* ssp. *frigida*, *Tofieldia coccinea*, *Zygadenus elegans*, *Salix reticulata*, *Alnus crispa*, *Polygonum viviparum*, *Delphinium glaucum*, *Aconitum delphinifolium*, *Anemone multifida* var. *hudsoniana*, *Saxifraga tricuspidata*, *Potentilla Ledebouriana*, *Astragalus alpinus*, *Hedysarum alpinum* var. *americanum*, *Empetrum nigrum*, *Epilobium angustifolium*, *Castilleja Raupii* ssp. *ursina*, *Pedicularis capitata*, *Pedicularis lanata*, *Campanula lasiocarpa*, *Solidago decumbens* var. *oreophila*, *Solidago multi-radiata* var. *scopulorum*, *Aster sibiricus*, *Antennaria rosea*, *Arnica lonchophylla* ssp. *genuina*.

Bryophytes and Lichens. Density very variable.

Cladonia sylvatica, *Cetraria cucullata*, *Cetraria islandica*, *Cetraria nivalis*, *Cetraria tilesii*, *Dactylina arctica*, *Alectoria ochroleuca*, *Aulacomnium palustre*, *Aulacomnium turgidum*, *Hylocomium splendens*.

B. Timberline Forest

Timberline in the Liard Range and on Nahanni Butte occurred around 3,800 feet. The forests at that elevation are of variable density, generally rather open, though sometimes formed of dense but separated groups of trees. The trees were short and often wind-deformed. The timberline forest is mixed and variable in composition of the tree layer. A well-defined shrub layer existed along with an open herb layer, but no underwood layer was noted. Bryophytes and lichens were not well represented, no layer being formed. In composition of the flora, these forests appear to be intermediate between the closed forests of lower elevations and the tundra of higher elevations. Vegetative composition is shown in Table 4.

In addition to the common mixed forest at timberline, one station was examined on the west slope of the Liard Range at an elevation of 3,500 to 3,700 feet. This station carried a closed forest of *Pinus contorta* var. *latifolia* with *Picea mariana* and *Abies lasiocarpa* as concomitant species. *Salix Barclayi* formed a sparse underwood.

TABLE 4. TIMBERLINE FOREST
(Mackenzie Mountains)

Tree		Shrub	Herb	Bryophyte and Lichen Generally sparse	
Seldom more than 15'. Variable density		3-4'. Rather dense	About 1'. Rather open		
PRIMARY SPECIES					
<i>Pinus contorta</i> var. <i>latifolia</i> , <i>Picea glauca</i> , <i>Abies lasiocarpa</i>	<i>Betula glandulosa</i> , <i>Alnus crispa</i>	<i>Epilobium angustifolium</i> , <i>Cornus canadensis</i> , <i>Linnaea borealis</i> var. <i>americana</i> , <i>Petasites palmatus</i>		<i>Cladonia sylvatica</i> , <i>Abietinella abietina</i> , <i>Pleurozium schreberi</i> , <i>Ptilium crista-castrensis</i> , <i>Hypocomium splendens</i> , <i>Polytrichum commune</i> , <i>Polytrichum juniperinum</i>	
SECONDARY AND OCCASIONAL SPECIES					
<i>Larix laricina</i> , <i>Picea mariana</i>	<i>Salix Bebbiana</i> , <i>Rosa</i> sp.	<i>Equisetum arvense</i> , <i>Equisetum pratense</i> , <i>Equisetum scirpoides</i> , <i>Equisetum sylvaticum</i> var. <i>pauciramosum</i> , <i>Lycopodium annotinum</i> , <i>Lycopodium complanatum</i> , <i>Abies lasiocarpa</i> (shrub), <i>Calamagrostis canadensis</i> , <i>Calamagrostis purpurascens</i> , <i>Trisetum spicatum</i> var. <i>molle</i> , <i>Bromus Pampellianus</i> , <i>Betula glandulosa</i> , <i>Alnus crispa</i> , <i>Aconitum delphinifolium</i> , <i>Rosa</i> sp., <i>Viola renifolia</i> var. <i>Brainerdii</i> , <i>Pyrola asarifolia</i> var. <i>purpurea</i> , <i>Pyrola secunda</i> , <i>Ledum groenlandicum</i> , <i>Vaccinium uliginosum</i> , <i>Vaccinium Vitis-Idaea</i> var. <i>minus</i> , <i>Polemonium acutiflorum</i> , <i>Mertensia paniculata</i> , <i>Solidago decumbens</i> var. <i>oreophila</i> , <i>Artemisia arctica</i> , <i>Arnica lonchophylla</i> ssp. <i>genuina</i>			

CORTICOLATES: None noted.

Species of shrub and herb layer comprised:

Abundant Species

Abies lasiocarpa (shrub), *Salix Barclayi*, *Betula glandulosa*, *Cornus canadensis*, *Vaccinium Vitis-Idaea* var. *minus*, *Linnaea borealis* var. *americana*.

Secondary Species

Lycopodium annotinum, *Lycopodium complanatum*, *Calamagrostis canadensis*, *Listera cordata*, *Geocaulon lividum*, *Empetrum nigrum*, *Epilobium angustifolium*, *Pyrola secunda*, *Ledum decumbens*, *Ledum groenlandicum*, *Vaccinium caespitosum*, *Vaccinium membranaceum*, *Pedicularis labradorica*, *Artemisia arctica*, *Petasites palmatus*.

Species of the bryophyte and lichen layer comprised the following:

Cladonia amaurocraea, *Dicranum fuscescens*, *Pleurozium schreberi*, *Hylocomium splendens*, *Polytrichum juniperinum*.

(This station may be representative of a high-elevation *Pinus contorta* var. *latifolia* vegetation type on the west slope of the Liard Range. Areas of apparently similar forest were seen from the air.)

C. *Abies lasiocarpa* Forest

The *Abies lasiocarpa* forest was noted only in the Liard Range between elevations of 2,600 to 3,800 feet. All stations examined were on the eastern slope. In this vegetation type the trees are short and often demonstrate a pronounced taper. The forest is composed of a high proportion of *Abies lasiocarpa*, only occasional *Picea glauca* and *Picea mariana* being present as associates. The underwood is generally sparse and on some stations entirely absent. There was no clear differentiation between shrub and herb layers. The bryophyte and lichen layer formed a dense carpet over the ground surface. The vegetation was poor in species and is shown in Table 5.

D. Mixed Coniferous Forest

The mixed coniferous forest of the Mackenzie Mountains was examined only in the Liard Range. It lay between the mixed mesophytic forests of the terrace and the *Abies lasiocarpa* forest of the mountains, between 1,600 and 2,600 feet. This vegetation type occupies a somewhat wide habitat range and, as a result, demonstrates considerable floristic variation. All the stations examined had a southeasterly or easterly exposure. Slopes vary from gentle to steep. Soils are shallow and strongly acidic. Vegetation of the mixed coniferous forest is shown in Table 6.

E. *Pinus contorta* var. *latifolia* – Lichen Woodland

This vegetation type was noted only in the Liard Range at elevations between 1,800 and 2,300 feet. Exposure was southeasterly and easterly. This forest grew on rocky knolls where the soil is very shallow. Exposures of bare rock are common, and often the trees are rooted in crevices. The lodgepole pine-lichen woodland demonstrates a distinctive physiognomy, characterized by extremely low density in the tree layer, complete absence of underwood, low density of the shrub and herb layers, and, relatively, an abundance of *Stereocaulon* and *Cetraria* forming a light-coloured lichen carpet on the forest floor. Vegetation is shown in Table 7.



A. Tundra in Liard Range, around 3,800 feet.



B. Dry rocky slope forest on Nahanni Butte.

TABLE 5. ABIES LASIOCARPA FOREST
(Mackenzie Mountains)

Tree	Underwood	Shrub and Herb	Bryophyte and Lichen
Up to 50'. Generally dense	Variable, up to 15'. Density, always sparse, sometimes absent	Up to 1-2'. Moderately dense, layer structure generally indistinct	Invariably a dense, continuous cover over whole ground surface
PRIMARY SPECIES	ALL SPECIES	PRIMARY SPECIES	
<i>Abies lasiocarpa</i>	<i>Abies lasiocarpa</i> , <i>Salix Barclayi</i>	<i>Abies lasiocarpa</i> (shrub and layer), <i>Cornus canadensis</i> , <i>Linnaea borealis</i> var. <i>americana</i>	<i>Hylacomium splendens</i> , <i>Pleurozium schreberi</i> , <i>Ptilium crista-castrensis</i>
SECONDARY SPECIES		SECONDARY AND OCCASIONAL SPECIES	
<i>Picea glauca</i> , <i>Picea mariana</i>		<i>Lycopodium annotinum</i> , <i>Betula glandulosa</i> , <i>Abies crispa</i> , <i>Sorbus scopulina</i> , <i>Rosa</i> sp., <i>Empetrum nigrum</i> , <i>Pyrola secunda</i> , <i>Ledum groenlandicum</i> , <i>Vaccinium membranaceum</i> , <i>Vaccinium uliginosum</i> , <i>Vaccinium Vitis-Idaea</i> var. <i>minus</i> , <i>Artemisia arctica</i>	<i>Peltigera aphthosa</i> , <i>Cladonia amaurocrea</i> , <i>Dicranum drummondii</i> , <i>Dicranum fuscicens</i> , <i>Mnium affine</i> , <i>Abietinella abietina</i> , <i>Polytrichum juniperinum</i> , <i>Ptilidium ciliare</i>

CORTICOLATES: The following were noted on *Abies lasiocarpa* branches: *Parmelia physodes*, *Parmelia pinastri*, *Cetraria pinastri*, *Cetraria saxipicola*, *Alectoria jubata*, *Usnea caucasica*.

TABLE 6. MIXED CONIFEROUS FOREST
(Mackenzie Mountains)

Tree	Underwood	Shrub	Herb	Bryophyte and Lichen
Up to 50'. Density, variable, often dense	10-15'. Density, generally sparse, sometimes absent	Up to 2-3'. Density very variable, sometimes absent, sometimes very dense, differentiation into shrub and herb layers sometimes poor	Less than 1'. Density, variable, often moderately dense	Density, rather variable, generally over 50% ground cover
PRIMARY SPECIES				
<i>Pinus contorta</i> var. <i>latifolia</i> , <i>Picea glauca</i> , <i>Picea mariana</i>	<i>Salix Barclayi</i> , <i>Alnus crispa</i>	<i>Alnus crispa</i>	<i>Cornus canadensis</i> , <i>Linnaea borealis</i> var. <i>americana</i>	<i>Hylacomium splendens</i>
SECONDARY SPECIES				
<i>Abies lasiocarpa</i> , <i>Populus tremuloides</i> , <i>Betula papyrifera</i>	<i>Salix Scouleriana</i>	<i>Abies lasiocarpa</i> (shrub), <i>Populus tremuloides</i> , <i>Sorbus scopulina</i> , <i>Rosa</i> sp., <i>Ledum groenlandicum</i> , <i>Viburnum edule</i>	<i>Lycopodium annotinum</i> , <i>Lycopodium clavatum</i> , <i>Lycopodium obscurum</i> var. <i>dendroideum</i> , <i>Calamagrostis canadensis</i> , <i>Maianthemum canadense</i> var. <i>interius</i> , <i>Mitella nuda</i> , <i>Ribes glandulosum</i> , <i>Rubus pubescens</i> , <i>Epilobium angustifolium</i> , <i>Pyrola asarifolia</i> var. <i>purpurea</i> , <i>Pyrola secunda</i> , <i>Vaccinium</i> <i>Vitis-Idaea</i> var. <i>minus</i> , <i>Petasites palmatus</i>	<i>Cladonia alpestris</i> , <i>Cladonia cornuta</i> , <i>Cladonia gracilis</i> var. <i>dilatata</i> , <i>Dicranum drummondii</i> , <i>Pleurozium schreberi</i> , <i>Ptilium crista-castrensis</i> , <i>Polytrichum commune</i> , <i>Polytrichum juniperinum</i>
OCCASIONAL SPECIES				
<i>Populus tremuloides</i> , <i>Betula papyrifera</i>	<i>Pinus contorta</i> var. <i>latifolia</i> , <i>Ribes triste</i> , <i>Spiraea Beaucardiana</i> , <i>Rubus strigosus</i>	<i>Equisetum sylvaticum</i> var. <i>pau-cinosum</i> , <i>Picea mariana</i> , <i>Hieracium alpinum</i> , <i>Agrostis scabra</i> , <i>Carex Deuceyana</i> , <i>Ribes triste</i> , <i>Fragaria glauca</i> , <i>Vaccinium membranaceum</i>	<i>Peltigera aphthosa</i> , <i>Cladonia sylvatica</i> , <i>Cladonia sylvatica</i> f. <i>sphagnoides</i> , <i>Stereocaulon paschale</i> , <i>Campylopus hispidulus</i> , <i>Drepanocladus uncinatus</i> , <i>Brachythecium salebrosum</i> , <i>Ptilidium ciliare</i>	

CONTIGUATES: Noted on *Picea mariana* branches were the following: *Parmelia physodes*, *Alcortia jubata*, and *Urena lapponica*. *Urena caucasica* was noted on *Pinus contorta* var. *latifolia* branches.

TABLE 7. PINUS CONTORTA VAR. LATIFOLIA - LICHEN WOODLAND
(Mackenzie Mountains)

Tree	Shrub	Herb	Bryophyte and Lichen
Up to 30'. Density, very open.	About 1-2'. Density, sparse to moderately dense.	Less than 1'. Density, generally sparse.	Density, over 75% cover.
PRIMARY SPECIES	ALL SPECIES	PRIMARY SPECIES	
<i>Pinus contorta</i> var. <i>latifolia</i>	<i>Pinus contorta</i> var. <i>latifolia</i> , <i>Picea glauca</i> , <i>Populus tremuloides</i> , <i>Betula papyrifera</i> var. <i>neotaskana</i> , <i>Alnus crispa</i>	<i>Empetrum nigrum</i> , <i>Vaccinium Vitis-Idaea</i> var. <i>minus</i>	<i>Cetraria nivalis</i> , <i>Stereocaulon paschale</i>
SECONDARY AND OCCASIONAL SPECIES	SECONDARY AND OCCASIONAL SPECIES		
<i>Picea glauca</i> , <i>Populus tremuloides</i> , <i>Betula papyrifera</i> var. <i>neotaskana</i>	<i>Agrostis scabra</i> , <i>Carex deflexa</i> , <i>Carex Deweyana</i> , <i>Maianthemum canadense</i> var. <i>interius</i> , <i>Salix Scouleriana</i> , <i>Betula papyrifera</i> , <i>Geocaulon lividum</i> , <i>Cornus canadensis</i> , <i>Pyrola secunda</i> , <i>Arctostaphylos rubra</i> , <i>Arctostaphylos Uva-ursi</i> , <i>Vaccinium uliginosum</i> , <i>Pedicularis labradorica</i> , <i>Arnica lousiana</i> ssp. <i>frigida</i>		
	<i>Cladonia mitis</i> , <i>Cladonia sylvatica</i> , <i>Cladonia uncialis</i> , <i>Cetraria cucullata</i> , <i>Polytrichum commune</i> , <i>Polytrichum piliferum</i>		

CORTICOLATES: None noted.

F. Dry Rocky Slope Forest

In one part of Nahanni Butte on a steep, rocky, south-facing slope, at an elevation of about 3,000 feet, there was a *Picea glauca*-*Pinus contorta* var. *latifolia* forest, floristically distinct from any other seen in the area. Information on this vegetation type is limited. Cones collected showed the white spruce to be *Picea glauca* var. *albertiana*. (This was the only positive varietal determination of white spruce obtained from the study.)

Shrub species noted were as follows: *Juniperus communis* var. *montana*, *Juniperus horizontalis*, *Populus balsamifera*, *Salix glauca*, *Betula glandulosa*, *Potentilla fruticosa*, and *Shepherdia canadensis*.

Significant species of the herb layer were *Bromus Pumpellianus*, *Zygadenus elegans*, *Pulsatilla Ludoviciana*, *Anemone parviflora*, *Saxifraga tricuspidata*, *Dryas integrifolia*, *Arctostaphylos Uva-ursi*, *Galium boreale*, and *Campanula rotundifolia*.

No bryophyte and lichen layer was noted.

II. THE MACKENZIE LOWLANDS

The sample taken in the Mackenzie Lowlands was small. From the air the Mackenzie Lowlands appeared to be occupied primarily by *Picea mariana* forest and brûlé. Other forest types covered only a small proportion of the area. In the sample area much of the land was of a hydromorphic soil character and supported *Picea mariana* forest. As shown by the descriptions which follow, this vegetation type differed floristically from the *Picea mariana* forests of the older floodplains and terraces. Depth of the peat layer in the hydromorphic soils of the Mackenzie Lowlands would appear to be less than that of similar soils in the older floodplains and terraces.

Soils of non-hydromorphic character apparently are glacial or fluvio-glacial in origin and contain an appreciable stone fraction, in contrast to the floodplain and terrace soils. Surface pH in upland soils of the Mackenzie Lowlands varied between 4.0 and 8.0. A large proportion of the upland soils examined were occupied by brûlé.

Species not previously recorded from the Mackenzie District and noted in this topographic division were *Glyceria striata* var. *stricta*, *Salix MacCalliana*, *Sorbus scopulina*, *Oxycoccus quadripetalus*, *Galium triflorum*, and *Adoxa moschatellina*. Well-represented families included *Salicaceae*, *Rosaceae*, and *Ericaceae*.

The vegetation of the Mackenzie Lowlands, lying in the area studied between 1,600 and 1,700 feet elevation, has been subdivided into four vegetation types, mixedwood (*Picea glauca*-*Populus tremuloides*) forest, *Picea mariana* forest, brûlé, and depressional shrub.

A. Mixedwood (*Picea glauca* - *Populus tremuloides*) Forest

This vegetation type appeared to be of relatively slight importance in the Mackenzie Lowlands. Much of the land believed previously to have carried this forest has been burned over. Soils are glacial or fluvio-glacial in origin, contain a substantial stone fraction, and are very variable in pH reaction. Vegetation is shown in Table 8.

TABLE 8. MIXEDWOOD (PICEA GLAUCA-POPULUS TREMULOIDES) FOREST
(Mackenzie Lowlands)

<i>Tree</i>	<i>Underwood</i>	<i>Shrub</i>	<i>Herb</i>	<i>Bryophyte and Lichen</i>
Up to 100'. Density, fully stocked.	10-20'. Density, 50-75% cover.	3-4'. Density, 50-75% cover.	Less than 1'. Density, 50-75% cover.	Density, very variable, generally rather low.
PRIMARY SPECIES				
<i>Picea glauca</i> , <i>Populus tremuloides</i>	<i>Betula papyrifera</i> , <i>Alnus crispa</i>	<i>Alnus crispa</i> , <i>Rosa</i> sp., <i>Viburnum edule</i>	<i>Cornus canadensis</i> , <i>Linnaca borealis</i> var. <i>americana</i>	<i>Hylocomium splendens</i>
SECONDARY AND OCCASIONAL SPECIES				
<i>Picea mariana</i> , <i>Populus balsamifera</i> , <i>Betula papyrifera</i>	<i>Populus balsamifera</i> , <i>Populus tremuloides</i> , <i>Betula papyrifera</i> var. <i>neodulaskana</i> , <i>Sorbus scopulina</i>	<i>Ribes glandulosum</i> , <i>Ribes hudsonianum</i> , <i>Ribes oxycanthoides</i> , <i>Rubus strigosus</i>	<i>Equisetum pratense</i> , <i>Equisetum scirpoides</i> , <i>Lycopodium annotinum</i> var. <i>alpestre</i> , <i>Lycopodium complanatum</i> , <i>Calamagrostis canadensis</i> , <i>Geocaldon lividum</i> , <i>Delphinium glaucum</i> , <i>Mitella nuda</i> , <i>Ribes triste</i> , <i>Rubus pubescens</i> , <i>Fragaria glauca</i> , <i>Epilobium angustifolium</i> , <i>Aralia nudicaulis</i> , <i>Moneses uniflora</i> , <i>Pyrola asarifolia</i> var. <i>purpurea</i> , <i>Pyrola secunda</i> , <i>Pyrola virens</i> , <i>Ledum groenlandicum</i> , <i>Vaccinium Vitis-Idaea</i> var. <i>minus</i> , <i>Mertensia paniculata</i> , <i>Galium boreale</i> , <i>Petasites palmatus</i>	<i>Pleurozium schreberi</i> , <i>Ptilium crista-castrensis</i>

CORTICOLATES: *Usnea sorediifera* and *Parmelia sulcata* were noted on the branches of *Picea glauca*.

TABLE 9. PICEA MARIANA FOREST
(Mackenzie Lowlands)

PRIMARY SPECIES				
Tree	Underwood	Shrub	Herb	Bryophyte and Lichen
Not over 50'. Density variable, generally open.	10-15'. Density, often absent, invariably of low density.	2-4'. Usually moderately dense, though sometimes absent as a distinct layer.	About 1'. Generally dense or very dense.	Invariably covering total ground surface.
<i>Picea mariana</i>	None	<i>Betula glandulosa</i> , <i>Alnus crispa</i>	<i>Equisetum arvense</i> , <i>Ledum groenlandicum</i>	<i>Tomenthypnum nitens</i> , <i>Hypocnum splendens</i>
SECONDARY SPECIES				
<i>Larix laricina</i>	<i>Betula papyrifera</i> , <i>Alnus crispa</i>	<i>Larix laricina</i> , <i>Picea mariana</i> , <i>Salix Scouleriana</i> , <i>Betula papyrifera</i> , <i>Ribes oxycanthoides</i> , <i>Potentilla fruticosa</i> , <i>Rosa</i> sp., <i>Shepherdia canadensis</i> , <i>Ledum groenlandicum</i> , <i>Viburnum cide</i> , <i>Lonicera glaucescens</i>	<i>Equisetum scirpoides</i> , <i>Equisetum sylvaticum</i> var. <i>pauciramosum</i> , <i>Picea mariana</i> , <i>Calamagrostis canadensis</i> , <i>Carex vaginata</i> , <i>Spiranthes Romanoffiana</i> , <i>Salix myrtillifolia</i> , <i>Geocaulon lividum</i> , <i>Delphinium glaucum</i> , <i>Mitella nuda</i> , <i>Rubus pubescens</i> , <i>Fragaria glauca</i> , <i>Potentilla fruticosa</i> , <i>Viola renifolia</i> var. <i>Brainerdii</i> , <i>Cornus canadensis</i> , <i>Arctostaphylos rubra</i> , <i>Vaccinium Vitis-Idaea</i> var. <i>minus</i> , <i>Mertensia paniculata</i> , <i>Linnaea borealis</i> var. <i>americana</i> , <i>Achillea nigrescens</i> , <i>Petasites palmatus</i> , <i>Senecio lugens</i>	<i>Peltigera aphthosa</i> , <i>Cladonia alpestris</i> , <i>Cladonia rangiferina</i> f. <i>setigera</i> , <i>Sphagnum warnatorfi-anum</i> , <i>Dicranum muchlenbeckii</i> , <i>Aulacomnium palustre</i> , <i>Calliergon giganteum</i> , <i>Pleurozium schreberi</i> , <i>Ptilium crista-castrensis</i>
OCCASIONAL SPECIES				
<i>Betula papyrifera</i>	<i>Salix arbusculoides</i> , <i>Salix Bebbiana</i> , <i>Salix Scouleriana</i> , <i>Betula glandulosa</i> , <i>Alnus incana</i>	<i>Juniperus communis</i> , <i>Populus tremuloides</i> , <i>Ribes hudsonianum</i> , <i>Ribes triste</i>	<i>Lycopodium annotinum</i> var. <i>alpestre</i> , <i>Smilacina trifoliata</i> , <i>Good- yera repens</i> var. <i>ophioides</i> , <i>Rubus acaulis</i> , <i>Rubus Chamacmoros</i> , <i>Epilobium angustifolium</i> , <i>Mon- ceses uniflora</i> , <i>Pyrola asarifolia</i> var. <i>purpurea</i> , <i>Pyrola virens</i> , <i>Oxycoccus quadripetalus</i> , <i>Pedi- cularis labradorica</i> , <i>Galium boreale</i> , <i>Adoxa Moschatellina</i>	<i>Climacium dendroides</i>

CONTICOLATES: None noted.

B. *Picea mariana* Forest

Picea mariana forest covers a large surface in the Mackenzie Lowlands and is probably the major forest type there. It occupies hydromorphic soils of wet depressional areas, gentle lower slopes, and creek bottoms. Soil drainage was assessed as poor. This vegetation type is rather rich in species. The tree layer usually is open, the trees being low in height. The underwood layer is poorly developed and sometimes absent. Differentiation between shrub and herb layers is not well defined, though the herb layer is almost always very dense. Vegetation is shown in Table 9.

C. Brûlé

All brûlés examined in the Mackenzie Lowlands were on upland soils. Floristically these stations appeared to be distinct from those of brûlé in floodplains and terraces.

Main Storey. In height 15 to 20 feet, sometimes less. Density, very dense.

Primary Species

Populus tremuloides.

Secondary Species

Pinus Banksiana, *Salix Bebbiana*, *Betula papyrifera* var. *neoalaskana*, *Alnus crispa*.

Occasional Species

Salix Barclayi, *Salix Scouleriana*.

Shrub Layer. In height 3 to 4 feet. Density, sometimes poorly defined, usually moderately dense.

Primary Species

Picea mariana.

Secondary Species

Picea glauca, *Salix Bebbiana*.

Occasional Species

Pinus Banksiana, *Larix laricina*, *Populus balsamifera*, *Salix Scouleriana*, *Betula papyrifera*, *Shepherdia canadensis*.

Herb Layer. Up to 2 feet in height. Density, generally rather open.

Primary Species

Picea glauca, *Picea mariana*.

Secondary Species

Calamagrostis canadensis, *Epilobium angustifolium*, *Linnaea borealis* var. *americana*.

Occasional Species

Abies lasiocarpa (seedling), *Habenaria hyperborea*, *Parnassia palustris* var. *neogaea*, *Rubus acaulis*, *Fragaria glauca*, *Potentilla fruticosa*, *Vicia americana*, *Cornus canadensis*, *Pyrola secunda*, *Arctostaphylos rubra*, *Mertensia paniculata*.

Bryophytes and Lichens. Density, very variable, never noted as a continuous layer.

Aulacomnium palustre, *Tomenthypnum nitens*, *Pleurozium schreberi*, *Ptilium crista-castrensis*, *Polytrichum juniperinum*.

Corticolates. *Cetraria pinastri* was noted on dead black spruce.

D. Depressional Shrub

This vegetation type occupied low-lying, poorly drained depressions of the topography. Because of limited sampling and of variation in the vegetation, the separation of species into groups was not advisable.

Main Storey. Arborescent shrub, 20 to 30 feet in height, Density, variable, generally dense.

Picea glauca, *Salix Barclayi**, *Salix Scouleriana*, *Alnus incana**.

Shrub Layer. In height 2 to 4 feet. Density, variable.

Picea glauca, *Ribes glandulosum*, *Ribes hudsonianum*, *Ribes oxycanthoides*, *Ribes triste*, *Rubus strigosus*, *Rosa* sp., *Cornus stolonifera*, *Viburnum edule*.

Herb Layer. One foot in height. Density, variable, generally dense.

Equisetum arvense, *Equisetum sylvaticum* var. *pauciramosum*, *Calamagrostis canadensis*, *Maianthemum canadense*, *Thalictrum sparsiflorum*, *Mitella nuda*, *Rubus pubescens*, *Fragaria vesca* var. *americana*, *Geum macrophyllum* ssp. *perincisum*, *Vicia americana*, *Viola renifolia* var. *Brainerdii*, *Epilobium angustifolium*, *Cornus canadensis*, *Mertensia paniculata*, *Galium boreale*, *Galium triflorum*, *Linnæa borealis* var. *americana*, *Petasites palmatus*, *Petasites sagittatus*.

Bryophytes and Lichens. Sparse.

Dicranum rugosum, *Mnium affine*, *Climacium dendroides*, *Polytrichum juniperinum*.

III. THE OLDER FLOODPLAINS AND TERRACES

A large sample was taken in the older floodplains and terraces division, and description of the vegetation is believed to be reasonably adequate, with

*Probably can be considered primary species.

the exception of the area around Fisherman Lake. This topographic division was variable in topography and soils, containing all degrees of slope from steep terrace banks to gently undulating point-bar deposits. Both upland and hydromorphic soil types occur. In the upland soils, all textures from sand to clay were noted. A similar variation was found in surface soil pH which ranges from 4.0 to 8.0. Acidic or slightly acidic soils were most prevalent. Some of the upland soils demonstrated the profile characteristics of the Grey-Wooded soil group. Hydromorphic soils were found mostly in back-swamp depressions of the older floodplains but were also noted in flats, benches, and gentle slopes of the terraces.

This topographic division supports a vegetative cover predominantly of forests in which broadleaved tree species are prominent. Three forest vegetation types were recognized, mixedwood (*Picea glauca*-*Populus tremuloides*) forest, mixed broadleaved forest, and *Picea mariana* forest. Other vegetation habitat types were meadow, shrub, channel and inundated areas, brûlé, and man-made clearings.

Species hitherto unrecorded in the Mackenzie District and noted in this topographic division comprise *Dicranum fragilifolium*, *Athyrium Filix-femina*, *Carex Bebbii*, *Carex retrorsa*, *Ranunculus septentrionalis*, *Thalictrum sparsiflorum*, *Cardamine pensylvanica*, *Oxycoccus quadripetalus*, *Impatiens biflora*, *Viola rugulosa*, *Circaea alpina*, *Aralia nudicaulis*, *Galium labradoricum*, *Galium triflorum*, and *Adoxa Moschatellina*.

A. Mixedwood (*Picea glauca* - *Populus tremuloides*) Forest

This vegetation type is one of the commonest in the area and occupies probably the largest area of any of the forest types. It has developed best on the older floodplains and terraces, being rare on the recent floodplains and apparently absent from the Mackenzie Mountains. In the Mackenzie Lowlands it appeared to occupy only a relatively small area. The mixedwood forest embraced a wide range of soil and topographic conditions, from steep terrace slopes of basic pH reaction to strongly acid sandy soils on the older floodplains. Soil drainage varied from well to moderately drained, and soil moisture from dry to fresh. This range of habitat factors is believed to be responsible for a corresponding variation in vegetation communities. The mixedwood forest of the older floodplains and terraces is rich in species, especially in the shrub and herb layers. All layers, except the bryophyte and lichen layer, are normally well developed. Vegetative composition is shown in Table 10, which can be regarded only as an aggregate of many stations differing one from another, sometimes quite markedly, in the presence, vigour, and relative abundance of the plant species.

B. Mixed Broadleaved Forest

The mixed broadleaved forest is almost entirely confined to the older floodplains and terraces, being relatively rare in the recent floodplains and absent from all other landtypes. On the older floodplains and terraces it occupied an appreciable area, though not so extensive as that covered by the mixedwood forest. Like the latter, it embraced a wide range of soil and topographic conditions. Soils were well to moderately drained, moderately acid to basic in pH reaction, and topography varied from flat to moderately

TABLE 10. MIXEDWOOD (PICEA GLAUCA - POPULUS TREMULOIDES) FOREST
(Older Floodplains and Terraces)

Tree Up to 100'. Density variable, often dense.	Underwood 15-20'. Density very variable, often well developed.	Shrub 2-4'. Density, generally dense.	Herb Up to 1'. Density variable, often rather open.	Bryophyte and Lichen Density, often greater than 50 per cent.
PRIMARY SPECIES				
<i>Picea glauca</i> , <i>Populus tremuloides</i>	<i>Salix Bebbiana</i> , <i>Betula papyrifera</i> , <i>Alnus crispa</i> , <i>Alnus incana</i> *	<i>Rosa</i> sp., <i>Viburnum edule</i>	<i>Mitella nuda</i> , <i>Rubus pubescens</i> , <i>Cornus canadensis</i> , <i>Linnæa bore-</i> <i>alis</i> var. <i>americana</i>	<i>Pleurozium schreberi</i> , <i>Hypnum</i> <i>splendens</i>
SECONDARY SPECIES				
<i>Populus balsamifera</i> , <i>Betula papy-</i> <i>rifera</i>	<i>Picea glauca</i> , <i>Populus tremuloides</i> , <i>Salix Barclayi</i>	<i>Picea glauca</i> , <i>Betula papyrifera</i> , <i>Alnus crispa</i> , <i>Ribes hudson-</i> <i>ianum</i> , <i>Ribes oxycanthoides</i> , <i>Shepherdia canadensis</i> , <i>Cornus</i> <i>stolonifera</i> *	<i>Equisetum arvense</i> , <i>Equisetum pra-</i> <i>tense</i> , <i>Equisetum scirpoides</i> , <i>Equisetum sylvaticum</i> var. <i>pau-</i> <i>cinosum</i> , <i>Picea glauca</i> , <i>Calamagrostis canadensis</i> , <i>Maianthemum canadense</i> var. <i>interius</i> , <i>Goodyera repens</i> , <i>Corallorhiza trifida</i> , <i>Actaea rubra</i> , <i>Ribes triste</i> , <i>Fragaria glauca</i> , <i>Lathyrus ochroleucus</i> , <i>Viola renifolia</i> var. <i>Brainerdii</i> , <i>Epilobium angustifolium</i> , <i>Aralia nudicaulis</i> , <i>Pyrola asarifolia</i> var. <i>purpurea</i> , <i>Pyrola secunda</i> , <i>Pyrola virens</i> , <i>Yuccinum</i> <i>Vitis-Idaea</i> var. <i>minus</i> , <i>Mertensia paniculata</i> , <i>Galium boreale</i>	<i>Peltigera aphthosa</i> , <i>Dicranum fragilifolium</i> , <i>Mnium affine</i> , <i>Platium crista-castrensis</i>
OCCASIONAL SPECIES				
<i>Pinus Banksiana</i> , <i>Picea mariana</i>	<i>Populus balsamifera</i> , <i>Amelanchier alnifolia</i>	<i>Picea mariana</i> , <i>Abies lasiocarpa</i> (semi-prostrate shrub), <i>Juniperus communis</i> , <i>Populus balsamifera</i> , <i>Populus tremuloides</i> , <i>Salix Bebbiana</i> , <i>Sorbus scopulina</i> , <i>Amelanchier alnifolia</i> , <i>Rubus strigosus</i> , <i>Ledum groenlandicum</i> , <i>Lonicera glaucescens</i>	<i>Lycopodium annolinum</i> var. <i>alpestre</i> , <i>Lycopodium complanatum</i> , <i>Picea mariana</i> , <i>Agropyron trachycalum</i> , <i>Carex concinna</i> , <i>Habenaria obtusata</i> , <i>Geocaulon lividum</i> , <i>Delphinium glaucum</i> , <i>Thalictrum sparsiflorum</i> , <i>Ribes glandulosum</i> , <i>Amelanchier alnifolia</i> , <i>Fragaria vesca</i> var. <i>americana</i> , <i>Circaea alpina</i> , <i>Moneses uniflora</i> , <i>Ledum groenlandicum</i> , <i>Pedicularis labradorica</i> , <i>Galium labradoricum</i> , <i>Galium triflorum</i> , <i>Aster ciliolatus</i> , <i>Petasites palustris</i>	<i>Cladonia rangiferina</i> , <i>Dicranum fuscescens</i> , <i>Dicranum muenkebeckii</i> , <i>Dicranum rugosum</i> , <i>Aulacomnium palustre</i> , <i>Timmia bavarica</i> , <i>Eurhynchium pulchellum</i> , <i>Polytrichum juniperinum</i> , <i>Ptilidium ciliare</i>

CORTICOLATES: *Parmelia sulcata* and *Evernia mesomorpha* were noted on *Betula papyrifera* stems.

*Generally bent represented on the floodplain.

TABLE 11. MIXED BROADLEAVED FOREST
(Older Floodplains and Terraces)

Tree	Underwood	Shrub	Herb	Bryophyte and Lichen
Up to and above 100'. Density variable, usually well-stocked.	10-25'. Density, very variable.	2-4'. Density, usually very dense.	Up to 1'. Density variable, usually rather dense.	Generally absent. Never covering over 5% of ground surface.
PRIMARY SPECIES				
<i>Populus balsamifera</i> , <i>Populus tremuloides</i> , <i>Betula papyrifera</i>	<i>Betula papyrifera</i> , <i>Alnus crispa</i> , <i>Alnus incana</i> *	<i>Alnus crispa</i> , <i>Rosa</i> sp., <i>Viburnum edule</i>	<i>Rubus pubescens</i> , <i>Cornus canadensis</i> , <i>Linnæa borealis</i> var. <i>americana</i>	ALL SPECIES <i>Cladonia alpestris</i> , <i>Timmia bavarica</i> , <i>Pleurozium schreberi</i> , <i>Rhytidiadelphus triquetrus</i> , <i>Hylacomium splendens</i>
SECONDARY SPECIES				
<i>Picea glauca</i>	<i>Picea glauca</i> , <i>Populus balsamifera</i> , <i>Populus tremuloides</i> , <i>Salix Bebbiana</i> *	<i>Picea glauca</i> , <i>Abies lasiocarpa</i> (semi-prostrate shrub), <i>Populus tremuloides</i> , <i>Betula papyrifera</i> , <i>Alnus incana</i> *, <i>Ribes oxycanthoides</i> , <i>Rubus strigosus</i> , <i>Shepherdia canadensis</i> , <i>Cornus stolonifera</i>	<i>Equisetum arvense</i> , <i>Equisetum pratense</i> , <i>Equisetum scirpoides</i> , <i>Equisetum sylvaticum</i> var. <i>pauciramiosum</i> **, <i>Lycopodium complanatum</i> **, <i>Picea glauca</i> , <i>Calamagrostis canadensis</i> , <i>Maianthemum canadense</i> var. <i>interius</i> , <i>Mitella nuda</i> , <i>Ribes oxycanthoides</i> , <i>Ribes triste</i> , <i>Rubus strigosus</i> , <i>Fragaria glauca</i> , <i>Lathyrus ochroleucus</i> , <i>Viola renifolia</i> var. <i>Brainerdii</i> *, <i>Epilobium angustifolium</i> , <i>Aralia nudicaulis</i> , <i>Pyrola asarifolia</i> var. <i>purpurea</i> , <i>Pyrola secunda</i> , <i>Pyrola virens</i> , <i>Mertensia paniculata</i> , <i>Galium boreale</i> , <i>Galium triflorum</i> *, <i>Aster ciliolatus</i> , <i>Petasites palmatus</i>	
OCCASIONAL SPECIES				
<i>Salix pseudomonticola</i> , <i>Betula papyrifera</i> var. <i>commutata</i> , <i>Amelanchier alnifolia</i>	<i>Juniperus communis</i> , <i>Populus balsamifera</i> , <i>Salix Bebbiana</i> , <i>Salix Scouleriana</i> , <i>Ribes glandulosum</i> , <i>Ribes hudsonianum</i> , <i>Ribes triste</i> , <i>Epilobium angustifolium</i> , <i>Lonicera glaucescens</i>	<i>Carex concinna</i> , <i>Habenaria orbiculata</i> , <i>Goodgera repens</i> var. <i>ophioides</i> , <i>Geocaulon lividum</i> , <i>Arenaria lateriflora</i> , <i>Actaea rubra</i> , <i>Ribes glandulosum</i> , <i>Ribes hudsonianum</i> , <i>Fragaria vesca</i> var. <i>americana</i> , <i>Vicia americana</i> , <i>Moneses uniflora</i> , <i>Arctostaphylos Uva-ursi</i> , <i>Vaccinium Vitis-Idaea</i> var. <i>minus</i> , <i>Pedicularis labradorica</i> , <i>Adoxa Moschatelina</i> , <i>Achillea nigrescens</i>		

CORTICOLATES: None noted.
* Generally best represented on the floodplains.
** Generally best represented on the terraces.

sloping. For this reason, as in the mixedwood forest, any listing of plant species is merely an approximation; one which extends even to the tree species since this vegetation type included a wide variety of forests, ranging from pure *Populus balsamifera*, pure *Populus tremuloides*, and pure *Betula papyrifera*, to mixed forest containing all three of the above species. The mixed broadleaved forest in vegetative composition showed many similarities to the mixedwood forest. Chief distinctions were a greater variability in the underwood layer, and the absence of a bryophyte and lichen layer in the mixed broadleaved forest. Vegetation is shown in Table 11.

C. *Picea mariana* Forest

The *Picea mariana* forest of the older floodplains and terraces is of relatively minor areal importance. It occupies two main topographic positions: (1) moderately drained moderate to gentle slopes and flats, (2) poorly drained depressions and flats. Corresponding to these two topographic situations, were two forest subtypes: (a) *Picea mariana*-feathermoss forest, (b) *Picea mariana*-*Larix laricina*-*Tomenthypnum nitens* forest. Of these the second subtype was by far the more prevalent, the first being relatively rare.

(a) *Picea mariana*-Feathermoss Forest

The *Picea mariana*-feathermoss forest is characterized in general by a relatively poor representation of bog species and in particular by the absence of *Tomenthypnum nitens*. Vegetative composition is shown in Table 12.

(b) *Picea mariana*-*Larix laricina*-*Tomenthypnum nitens* Forest

This vegetation type represents the true black spruce bog of the older floodplains and terraces, as distinct from the "upland" black spruce-feathermoss forest. The presence of *Tomenthypnum nitens* and *Sphagnum* spp. characterized these black spruce bogs. In vegetative composition (cf. Tables 12, 13) these bogs are much richer than the black spruce-feathermoss forest and support a much more hydrophytic flora. In addition, the tree layer is shorter and less dense. Vegetative composition is shown in Table 13.

D. Meadow

Only one station was examined in the meadow vegetation type. Wide expanses of meadow were seen from the air in the Liard-Nétla confluence area.

On the edge of the meadow station the following were noted: *Equisetum pratense*, *Calla palustris*, *Salix planifolia*, *Alnus incana*, *Ribes hudsonianum*, *Petasites sagittatus*, and *Carex disperma*. The main components of the meadow were *Carex atherodes* and *Calamagrostis canadensis*.

E. Shrub, Channel and Inundated Areas

One arborescent shrub community was examined. Component species were *Alnus incana* and *Salix planifolia*. A pure stand of *Calamagrostis canadensis* was present beneath the shrub layer.

Only one channel was examined. The channel was fringed by *Salix Barclayi* and *Salix Bebbiana*. Dominant species of the herb layer were



A. *Picea mariana*-*Larix laricina*-*Tomenthypnum nitens* forest of the older floodplains. (The dark layer in the upper soil is peat, overlying a grey clay soil.)



B. Mixedwood (white spruce-white birch-aspen) forest of the older floodplains.

TABLE 12. PICEA MARIANA - FEATHERMOSS FOREST
(Older Floodplains and Terraces)

<i>Tree</i>	<i>Underwood</i>	<i>Shrub</i>	<i>Herb</i>	<i>Bryophyte and Lichen</i>
Up to 50'. Density, generally rather dense.	6-12'. Density, sometimes absent, usually very sparse.	2-3'. Density, generally not exceeding 50% of ground surface, sometimes very poorly defined.	Less than 1'. Density, generally not exceeding 50% of ground surface.	Invariably dense, covering over 75% of ground surface.
PRIMARY SPECIES				
<i>Picea mariana</i>	<i>Alnus crispa</i>	<i>Alnus crispa</i>	<i>Equisetum scirpoides</i> , <i>Cornus canadensis</i> , <i>Vaccinium Vitis-Idaea</i> var. <i>minus</i>	<i>Hylocomium splendens</i>
SECONDARY SPECIES				
<i>Betula papyrifera</i>	<i>Salix Bebbiana</i> , <i>Betula papyrifera</i>	<i>Picea mariana</i> , <i>Ribes triste</i> , <i>Rosa</i> sp., <i>Ledum groenlandicum</i> , <i>Viburnum edule</i>	<i>Equisetum arvense</i> , <i>Equisetum pratense</i> , <i>Carex concinna</i> , <i>Geocaulon lividum</i> , <i>Mitella nuda</i> , <i>Linnæa borealis</i> var. <i>americana</i> , <i>Petasites palmatus</i>	<i>Peltigera aphthosa</i> , <i>Cladonia alpestris</i> , <i>Pleurozium schreberi</i> , <i>Ptilium crista-castrensis</i>
OCCASIONAL SPECIES				
	<i>Betula papyrifera</i> , <i>Ribes hudsonianum</i> , <i>Ribes oxycanthoides</i>	<i>Salix Bebbiana</i> (dwarf shrub), <i>Salix myrtillofolia</i> , <i>Pyrola vitifolia</i> , <i>Arctostaphylos rubra</i> , <i>Mertensia paniculata</i>	<i>Cladonia rangiferina</i> , <i>Dicranum bergeri</i> , <i>Dicranum fragilifolium</i> , <i>Dicranum rugosum</i> , <i>Aulacomnium palustre</i> , <i>Ptilidium ciliare</i>	

CORTICOLATES: None noted.

TABLE 13. PICEA MARIANA - LARIX LARICINA - TOMENTHYPNUM NITENS FOREST
(Older Floodplains and Terraces)

Tree		Shrub	Herb	Bryophyte and Lichen
Never more than 30', often much less, frequently only 10'. Density, variable, usually open.		1-3'. Density, sometimes very poorly defined, very variable.	Less than 1'. Generally dense.	Invariably covering total ground surface.
PRIMARY SPECIES				
Larix laricina, Picea mariana	Larix laricina, Picea mariana, Betula glandulosa, Ledum groenlandicum	No species was constantly dominant on all stations. Important secondary species were: Equisetum arvense, Equisetum scirpoides, Equisetum sylvaticum var. pauciramosum, Smilacina trifoliata, Rubus Chamacmorus, Arctostaphylos rubra, Oryzopsis quadripetala, Vaccinium Vitis-Idaea var. minus	Sphagnum warstorfianum, Tomenthypnum nitens, Hylocomium splendens	
SECONDARY SPECIES				
None	Salix pedicellaris var. hypoglauca, Potentilla fruticosa, Rosa sp., Andromeda Polifolia, Chamaedaphne calyculata, Vaccinium uliginosum	Arctagrostis arundinacea, Carex capillaris var. elongata, Carex scirpoides, Salix myrtillofolia, Geocaulon lividum, Anemone parviflora, Mitella nuda, Viola renifolia var. Brainerdii, Cornus canadensis, Pedicularis labradorica, Galium boreale, Petasites palmatus, Petasites sagittatus	Peltigera apthosa, Cladonia alpestris, Cladonia rangiferina, Sphagnum magellanicum, Sphagnum recurvum, Autocomnium palustre, Pleurozium schreberi	
OCCASIONAL SPECIES				
Pinus Banksiana, Salix mackenziana, Betula papyrifera	Populus tremuloides, Betula pumila var. glandulifera, Alnus crispa, Alnus incana, Ribes hudsonianum	Equisetum limosum, Calamagrostis canadensis, Carex aquatilis, Tofieldia occidentalis, Zygodenus elegans, Habenaria orbiculata, Spiranthus Romanoffiana, Drosera rotundifolia, Parnassia palustris var. neogaea, Rubus aculeis, Potentilla palustris, Empetrum nigrum, Moneses uniflora, Pyrola virens, Galium labradoricum, Galium triflorum, Linnaea borealis var. americana, Aster ciliolatus	Cladonia sylvatica, Cetraria nivalis, Sphagnum teres, Diceranum bergeri, Munium affine, Polytrichum juniperinum var. alpestre	

CORTICULATES: None noted.

Equisetum arvense, *Eleocharis palustris*, *Carex rostrata*, and *Mentha arvensis* var. *villosa*. Other species were *Ranunculus septentrionalis*, *Rorippa islandica*, *Cardamine pensylvanica*, *Sium suave*, *Veronica scutellata*, and *Galium labradoricum*.

The only inundated area noted supported a pure stand of *Equisetum limosum*.

F. Brûlé

Brûlé on the older floodplains and terraces appeared to be divisible into two classes, based upon the dominance of either *Calamagrostis canadensis* or *Equisetum pratense* in the herb layer.

For the purposes of this paper, brûlé will be considered as a single category. Vegetative composition is shown in Table 14.

PLATE IV



Carex atherodes meadow in the older floodplains.

G. Man-made Clearings

The trapper's clearings of the area showed a varied flora. Species noted as conspicuous in this vegetation were *Calamagrostis canadensis*, *Urtica gracilis*, *Lathyrus ochroleucus*, and *Epilobium angustifolium*.

Intensified exploratory activity for oil has resulted in the creation of many cleared lines for seismic work. One such seismic line near Fort Liard yielded the following species:

TABLE 14. BRÛLÉ
(Older Floodplains and Terraces)

<i>Main Story</i>	<i>Shrub</i>	<i>Herb</i>	<i>Bryophyte and Lichen</i>
Arborescent shrub, usually 20-30'. Density very variable, often dense.	3-5'. Density variable, often dense, but sometimes poorly defined and intergrading with the herb layer.	1-2'. Usually very dense.	Generally absent save on dead wood, rarely a discontinuous and sparse layer on soil and deadfall.
PRIMARY SPECIES			
<i>Populus tremuloides</i> , <i>Salix Baccata</i> , <i>Salix Bebbiana</i> , <i>Betula papyrifera</i>	No species demonstrated constant dominance. Important secondary species were: <i>Picea glauca</i> , <i>Rosa</i> sp., <i>Cornus stolonifera</i> , <i>Viburnum ciliatum</i>	<i>Equisetum pratense</i> , <i>Calamagrostis canadensis</i> , <i>Epilobium angustifolium</i>	<i>Peltigera aphthosa</i> , <i>Cladonia alpestris</i> , <i>Cladonia rangiferina</i> , <i>Dicranum fragilifolium</i> , <i>Aulacomnium palustre</i> , <i>Tomenthypnum nitens</i> , <i>Placozium schreberi</i> , <i>Pylaisia polyantha</i> , <i>Ptilium crista-castrensis</i> , <i>Hypocnum splendens</i> , <i>Polytrichum juniperinum</i>
SECONDARY SPECIES			
<i>Populus balsamifera</i> , <i>Betula papyrifera</i> var. <i>neotaskana</i> , <i>Alnus crispa</i> , <i>Alnus incana</i>	<i>Salix Baccata</i> , <i>Salix Bebbiana</i> , <i>Betula papyrifera</i> , <i>Alnus crispa</i> , <i>Ribes ludsonianum</i> , <i>Ribes oxycanthoides</i> , <i>Rubus strigosus</i> , <i>Shepherdia canadensis</i>	<i>Equisetum arvense</i> , <i>Picea glauca</i> , <i>Mitella nuda</i> , <i>Ribes triste</i> , <i>Rubus pubescens</i> , <i>Prunaria glauca</i> , <i>Vicia americana</i> , <i>Lathyrus ochroleucus</i> , <i>Viola renifolia</i> var. <i>Brainardii</i> , <i>Cornus canadensis</i> , <i>Mertensia paniculata</i> , <i>Galium boreale</i> , <i>Linnaea borealis</i> var. <i>americana</i>	
OCCASIONAL SPECIES			
<i>Larix laricina</i> , <i>Picea glauca</i>	<i>Salix arbusculoides</i> , <i>Betula glandulosa</i> , <i>Alnus incana</i> , <i>Ribes lacustre</i>	<i>Habenaria hyperborea</i> , <i>Oxytropis retrofracta</i> , <i>Pyrola asarifolia</i> var. <i>purpurea</i> , <i>Pyrola virens</i> , <i>Ledum granuladum</i> , <i>Galium triflorum</i> , <i>Aster ciliolatus</i>	

CORTICOLATES: Absent.

Athyrium Filix-femina, *Equisetum arvense*, *Poa alpigena*, *Poa palustris*, *Glyceria maxima*, *Glyceria pulchella*, *Agropyron subsecundum*, *Eleocharis palustris*, *Carex Bebbii*, *Carex Deweyana*, *Carex retrorsa*, *Carex rostrata*, *Chenopodium capitatum*, *Stellaria longifolia*, *Aquilegia brevistyla*, *Delphinium glaucum*, *Ranunculus Macounii*, *Ranunculus Purshii*, *Thalictrum sparsiflorum*, *Corydalis aurea*, *Descurainia sophioides*, *Potentilla norvegica*, *Lathyrus ochroleucus*, *Geranium Bicknellii*, *Viola rugulosa*, *Epilobium glandulosum* var. *adenocaulon*, *Aralia nudicaulis*, *Sium suave*, *Dracocephalum parviflorum*, *Mentha arvensis* var. *villosa*, *Scutellaria galericulata*, *Stachys palustris* var. *pilosa*, *Plantago major* var. *asiatica*, *Solidago lepida* var. *elongata*, *Aster sibiricus*.

IV. THE RECENT FLOODPLAINS

Though the recent floodplains comprise a small proportion of the area, they support some of the most productive forest. The recent floodplains are narrow strips bordering the river or islands in the river. Topography is uniform, consisting of gently undulating point-bar deposits, interrupted by backswamps and channels. The soils are likewise rather uniform, juvenile, grey in colour, relatively light in texture, and 7.0 to 8.0 in pH reaction. Forest is the main component of the vegetation, though shrub cover is more abundant than on any other topographic division.

Species hitherto unrecorded in the Mackenzie District and noted on this zone were *Entodon cladorrhizans*, *Pteritis nodulosa*, *Carex festivella*, *Streptopus amplexifolius*, *Astragalus americanus*, *Circaea alpina*, *Aralia nudicaulis*, *Galium triflorum*, and *Aster praealtus*. The vegetation of the recent floodplains is easily divisible into two main categories; the first, that occupying unstable habitats, for example sandbar and river-bank vegetation, riparian shrub, along with some stations of the balsam poplar forest; the second, the other forest and shrub types occupying more stable habitats. In the first category, some species of the *Equisetaceae*, along with the *Gramineae*, *Salicaceae*, *Leguminosae*, and *Compositae*, comprise a high proportion of the vegetation. In more stable habitats *Equisetum pratense*, along with the *Cornaceae*, *Pyrolaceae*, and *Caprifoliaceae*, is best represented.

In particular, the recent floodplains contain a group of species which are abundant and vigorous there, but which are less well-developed on any of the other topographic divisions and, without exception, are almost entirely absent from the Mackenzie Mountains. These species are *Pteritis nodulosa*, *Populus balsamifera*, *Salix interior* var. *pedicellata*, *Salix lasiandra* var. *recompens*, *Alnus incana*, *Ribes oxycanthoides*, *Circaea alpina*, *Cornus stolonifera*, *Galium boreale*, *Galium triflorum*, and *Viburnum edule*.

Six vegetation types were recognized in the recent floodplains: sandbars and river-banks, riparian shrub, depressional shrub, *Populus balsamifera* forest, *Picea glauca* forest, and brûlé.

A. Sandbars and River-banks

Sandbars and river-banks supported a widely varied flora of low density which seldom showed any assemblage of recognizable communities. Aside from the effect of chance in variation between stations, the age of each bar, along with the periodicity and duration of flooding, appeared also to have an

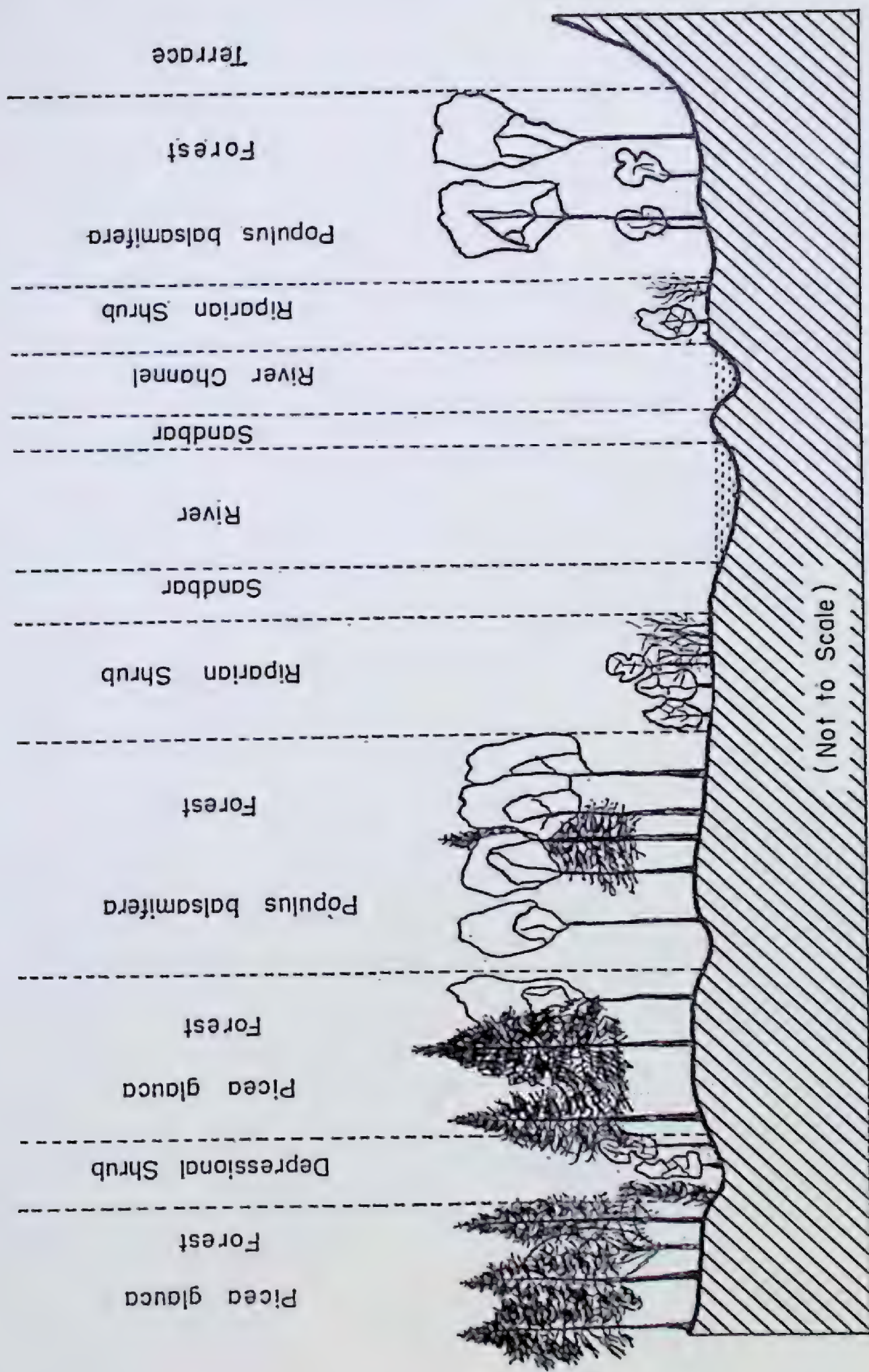


FIGURE 6. Diagrammatic representation of vegetation types in the recent floodplains.

effect upon the composition of the flora. Plants noted in this habitat were as follows: *Equisetum arvense*, *Equisetum hiemale* var. *californicum*, *Equisetum palustre*, *Equisetum pratense*, *Picea glauca* (seedlings), *Cinna latifolia*, *Agrostis scabra*, *Calamagrostis canadensis*, *Deschampsia caespitosa*, *Trisetum spicatum* var. *molle*, *Beckmannia Syzigachne*, *Poa alpigena*, *Glyceria pulchella*, *Agropyron trachycaulum*, *Elymus canadensis*, *Eleocharis palustris*, *Juncus balticus*, *Populus balsamifera* (seedlings and sprouts), *Salix interior* var. *pedicellata* (seedlings), *Salix lasiandra* var. *recompens* (seedlings), *Alnus incana* (seedlings), *Chenopodium capitatum*, *Rorippa islandica* var. *microcarpa*, *Arabis hirsuta* ssp. *pycnocarpa*, *Potentilla norvegica*, *Potentilla yukonensis*, *Dryas Drummondii*, *Astragalus alpinus*, *Astragalus tenellus*, *Oxytropis splendens*, *Hedysarum Mackenzii*, *Vicia americana*, *Cornus stolonifera*, *Gentiana Raupii*, *Solidago lepida* var. *clongata*, *Aster falcatus*, *Aster sibiricus*, *Erigeron philadelphicus*, *Achillea nigrescens*, *Artemisia canadensis*, *Artemisia Tilesii* var. *elatior*, and *Lactuca pulchella*.

B. Riparian Shrub

The riparian shrub vegetation on the recent floodplains of Liard River showed the typical "step" profile of ligneous vegetation colonizing new fluvial deposits (Raup, 1935: 77; Jeffrey, 1959: 4). This vegetation was dominated by *Salix* spp., *Alnus incana*, and *Populus balsamifera*. Three communities were easily recognized, (1) *Salix*, (2) *Salix-Alnus*, (3) *Populus-Alnus*. In order, these represent a catenulate progression with increasing distance from the river shore. For the purposes of this paper the plants of the riparian shrub are considered as belonging to one vegetation type. Owing to variation in species composition, it was not considered feasible to assess plant status in this vegetation type.

Main Storey. Arborescent shrub, usually 10 to 30 feet in height. Density, generally dense.

Populus balsamifera, *Salix arbusculoides**, *Salix Bebbiana*, *Salix interior* var. *pedicellata*, *Salix lasiandra* var. *recompens*, *Salix pseudomonticola**, *Alnus incana*.

Shrub Layer. Three to four feet in height. Density, sometimes absent, generally sparse.

Populus balsamifera, *Alnus incana*, *Ribes oxycanthoides*, *Rubus strigosus**, *Rosa* sp., *Shepherdia canadensis**, *Cornus stolonifera*, *Viburnum edule**.

C. Depressional Shrub

Herb Layer. Height variable, generally 1 to 2 feet in height. Density, generally sparse.

*Pteritis nodulosa**, *Equisetum arvense*, *Equisetum hiemale* var. *californicum*, *Equisetum palustre*, *Equisetum pratense*, *Picea glauca* (seedlings), *Cinna latifolia*, *Calamagrostis canadensis*, *Agropyron trachycaulum*, *Habenaria hyperborea**, *Mitella nuda**, *Ribes glandulosum*, *Ribes triste*, *Rubus pubescens*,

*Occasional species, not common in this vegetation type.



A. Riparian vegetation of the recent floodplain; balsam poplar forest in background.



B. White spruce forest of the recent floodplain (white spruce-balsam poplar forest subtype).

Hedysarum Mackenzii, *Vicia americana*, *Cornus canadensis**, *Pyrola asarifolia* var. *purpurea**, *Mertensia paniculata*, *Galium boreale*, *Galium triflorum*, *Linnæa borealis* var. *americana**, *Solidago lepida* var. *elongata*, *Aster praealtus**, *Aster sibiricus*, *Erigeron philadelphicus*, *Achillea nigrescens*, *Artemisia Tilesii* var. *elatior*, *Petasites palmatus**.

Bryophytes and Lichens. Absent.

This vegetation type occupies low-lying depressional areas (back-swamps) of the recent fluvial deposits. Floristically, it is much more stable than the riparian shrub type of the river margin. The number of species is less, and the vegetation demonstrates a consistently layered physiognomy that was not always present in riparian shrub. Limited sampling made assessment of plant status inadvisable.

Main Storey. Arborescent shrub, 10 to 30 feet in height. Density variable, often dense.

Populus balsamifera, *Salix arbusculoides**, *Salix Barclayi**, *Salix Bebbiana*, *Alnus incana*.

Shrub Layer. In height 2 to 4 feet. Density variable, often dense.

Pteritis nodulosa, *Picea glauca**, *Ribes glandulosum*, *Ribes hudsonianum**, *Ribes lacustre**, *Ribes oxycanthoides*, *Rubus strigosus*, *Rosa* sp., *Cornus stolonifera*, *Viburnum edule*.

Herb Layer. Up to 1 to 2 feet in height. Density, generally dense.

Pteritis nodulosa, *Equisetum pratense*, *Calamagrostis canadensis*, *Actaea rubra**, *Mitella nuda*, *Ribes triste*, *Rubus pubescens*, *Circaea alpina**, *Galium boreale*.

In marked contrast to the riparian shrub where vegetation development and growth were hampered by periodic inundation, the vegetation of this type was generally dense in all layers, and a much higher proportion of the growing space was utilized.

D. *Populus balsamifera* Forest

Balsam poplar forest is common along lower Liard River, occupying many stations of the recent point-bar deposits. Balsam poplar stems have attained great size, growing to over 100 feet in height and up to almost 4 feet in diameter at breast height. Floristically, this vegetation type is simple, the number of species represented being small. The balsam poplar forest was easily divided into three convenient subtypes:

- (1) *Populus balsamifera*-*Equisetum hiemale* var. *californicum* forest
- (2) *Populus balsamifera*-*Equisetum pratense* forest
- (3) *Populus balsamifera*-*Picea glauca* forest

*Occasional species.

TABLE 15. POPULUS BALSAMIFERA FOREST
(Recent Floodplains)

<i>Tree</i>	<i>Underwood</i>	<i>Shrub</i>	<i>Herb</i>	<i>Byrophyte and Lichen</i>
Up to and over 100'. Generally dense.	20-30'. Generally dense.	3-5'. Generally dense, though sometimes sparse in young stands.	1-2'. Invariably dense.	No layer formation, very sparsely distributed, almost invariably on dead wood.
ALL SPECIES				
<i>Populus balsamifera</i>	<i>Populus balsamifera</i> (root sprouts), <i>Alnus incana</i>	<i>Alnus incana</i> , <i>Rosa</i> sp., <i>Cornus stolonifera</i>	<i>Equisetum hiemale</i> var. <i>californicum</i> , <i>Equisetum pratense</i>	<i>Peltigera apthosa</i> , <i>Cladonia gracilis</i> var. <i>dilatata</i> f. <i>dilacerata</i> , <i>Cladonia rangiferina</i> , <i>Ceratodon purpureus</i> , <i>Peltia nutans</i> , <i>Mnium affine</i> , <i>Aulacomnium palustre</i> , <i>Timmia bavarica</i> , <i>Drepanocladus uncinatus</i> , <i>Brachythecium salebratum</i> , <i>Eurhynchium pulchellum</i> , <i>Pleurozium schreberi</i> , <i>Ptilium crista-castrensis</i> , <i>Hypoxomium splendens</i> , <i>Polytrichum juniperinum</i>
PRIMARY SPECIES				
<i>Picea glauca</i>	<i>Picea glauca</i>	<i>Picea glauca</i> , <i>Ribes oxycanthoides</i> , <i>Viburnum edule</i>	<i>Equisetum arvense</i> , <i>Picea glauca</i> , <i>Calamagrostis canadensis</i> , <i>Rubus pubescens</i> , <i>Vicia americana</i> , <i>Galium boreale</i>	
SECONDARY SPECIES				
OCCASIONAL SPECIES				
	<i>Salix arbusculoides</i> , <i>Salix Bebbiana</i> , <i>Betula papyrifera</i> , <i>Amelanchier alnifolia</i>	<i>Pteritis nodulosa</i> , <i>Ribes hudsonianum</i> , <i>Amelanchier alnifolia</i> , <i>Rubus strigosus</i>	<i>Equisetum scirpoides</i> , <i>Cinna latifolia</i> , <i>Carex Deweyana</i> , <i>Actaea rubra</i> , <i>Delphinium glaucum</i> , <i>Circuea alpina</i> , <i>Cornus canadensis</i> , <i>Moneses uniflora</i> , <i>Pyrola asarifolia</i> var. <i>purpurea</i> , <i>Pyrola secunda</i> , <i>Pyrola virens</i> , <i>Mertensia paniculata</i> , <i>Galium triflorum</i> , <i>Linnaea borealis</i> var. <i>americana</i> , <i>Aster ciliolatus</i> , <i>Aster sibiricus</i> , <i>Artemisia Tilesii</i> var. <i>elatior</i>	

CORTICOLATES: Pylaisia polyantha was commonly noted on balsam poplar boles.

TABLE 16. PICEA GLAUCA FOREST
(Recent Floodplains)

Tree	Underwood	Shrub	Herb	Bryophyte and Lichen
Up to and over 100'. Generally dense.	15-25'. Generally dense.	3-5'. Generally dense.	1-2'. Generally dense.	Density, generally over 75% cover. In marked contrast to the <i>Populus balsamifera</i> forest, a well-developed bryophyte layer commonly existed.
PRIMARY SPECIES				
<i>Picea glauca</i>	<i>Picea glauca</i> , <i>Betula papyrifera</i> , <i>Alnus incana</i>	<i>Alnus incana</i> , <i>Rosa</i> sp., <i>Cornus stolonifera</i> , <i>Viburnum edule</i>	<i>Equisetum pratense</i> , <i>Mitella nuda</i> , <i>Rubus pubescens</i> , <i>Cornus canadensis</i>	<i>Pleurozium scheucheri</i> , <i>Ptilium crista-castrensis</i> , <i>Hylacomium splendens</i>
SECONDARY SPECIES				
<i>Populus balsamifera</i> , <i>Betula papyrifera</i> , <i>Betula papyrifera</i> var. <i>commutata</i> , <i>Betula papyrifera</i> var. <i>neolaskeana</i>	<i>Populus balsamifera</i> , <i>Salix Bebbiana</i> , <i>Betula papyrifera</i> var. <i>commutata</i>	<i>Picea glauca</i> , <i>Betula papyrifera</i> , <i>Betula papyrifera</i> var. <i>commutata</i> , <i>Ribes oxycanthoides</i> , <i>Amenchier alnifolia</i>	<i>Equisetum scirpoides</i> , <i>Picea glauca</i> , <i>Calamagrostis canadensis</i> , <i>Maianthemum canadense</i> var. <i>interius</i> , <i>Gaultheria repens</i> var. <i>ophioides</i> , <i>Delphinium glaucum</i> , <i>Ribes triste</i> , <i>Rubus strigosus</i> , <i>Fragaria glauca</i> , <i>Rosa</i> sp., <i>Viola renifolia</i> var. <i>Brainerdii</i> , <i>Circaea alpina</i> , <i>Aralia nudicaulis</i> , <i>Moneses uniflora</i> , <i>Pyrola asarifolia</i> var. <i>purpurea</i> , <i>Pyrola secunda</i> , <i>Pyrola virens</i> , <i>Mertensia paniculata</i> , <i>Galium boreale</i> , <i>Galium triflorum</i> , <i>Linnaea borealis</i> var. <i>americana</i>	<i>Peltigera aphthosa</i> , <i>Minium affine</i> , <i>Drepanocladus uncinatus</i> , <i>Eurhynchium pulchellum</i> , <i>Rhytidiadelphus triquetrus</i>
OCCASIONAL SPECIES				
<i>Populus tremuloides</i>	<i>Populus tremuloides</i> , <i>Salix Bebbiana</i> , <i>Alnus crispa</i>	<i>Salix Barclayi</i> , <i>Salix Bebbiana</i> , <i>Alnus crispa</i> , <i>Ribes lacustre</i> , <i>Ribes triste</i> , <i>Shepherdia canadensis</i> , <i>Lonicera glaucescens</i>	<i>Equisetum hiemale</i> var. <i>californicum</i> , <i>Arctagrostis arundinacea</i> , <i>Carex concinna</i> , <i>Maianthemum canadense</i> , <i>Streptopus amplexifolius</i> , <i>Aclaea rubra</i> , <i>Viola rugulosa</i> , <i>Epilobium angustifolium</i> , <i>Petasites palmatus</i> , <i>Taraxacum dumetorum</i>	<i>Timmia bararica</i> , <i>Entodon cladorrhizans</i> (Many of the species listed as growing on dead wood in the <i>Populus balsamifera</i> forest were also found in the same growth medium in this forest type).

CORTICOLATES: *Eurhynchium pulchellum* was commonly found on white spruce buttresses. *Usnea cavernosa* was common on white spruce branches. Also noted on white spruce were *Parmelia phaeodes*, *Evernia mesomorpha*, *Physcia grisea*, *Physcia orbicularis*, *Orthotrichum apiculatum*.

For the purposes of this paper, the flora of the *Populus balsamifera* forest will be considered to belong to one vegetation type. Vegetation is shown in Table 15.

E. *Picea glauca* Forest

This vegetation type corresponds to the "floodplain white spruce forest" of Raup, 1934: 85-87; 1935: 72; 1946: 45-46; 1947: 35.

The *Picea glauca* forest of the recent floodplains is one of the most important forest types of the area. The stations which it occupies appear, in general, to be somewhat better drained and at slightly higher elevations than the *Populus balsamifera* forest. It was possible to subdivide the *Picea glauca* forest into two major subtypes:

- (1) *Picea glauca*-*Populus balsamifera* forest
- (2) *Picea glauca*-*Betula papyrifera* forest

In this paper the *Picea glauca* forest of the recent floodplains will be treated as one type, without division into subtypes.

The *Picea glauca* forest is richer in species than the *Populus balsamifera* forest. The colonizing species of riparian deposition were seldom noted in this more stable vegetation type. Vegetative composition is given in Table 16.

F. Other Forest Vegetation Types

Forests other than the main types already described also occur on the recent floodplains but are too limited in extent to merit separate attention. They contained few species not already mentioned. These forests comprised mixedwood (*Picea glauca*-*Populus tremuloides*) and mixed broadleaved (*Betula papyrifera*-*Populus tremuloides*-*Populus balsamifera*) forest types.

G. Brûlé

The brûlés of the recent floodplains are interesting in that their flora differs considerably from that of other areas. Notably they contain species which are most abundant and vigorous in the forest and shrub types of this topographic division, and, in addition, the proportion of *Populus tremuloides* is much reduced in comparison to other landtypes.

Main Storey. Arborescent shrub, 15 to 25 feet in height. Density, generally dense.

Primary Species

Populus balsamifera, *Salix Bebbiana*, *Betula papyrifera*, *Alnus incana*.

Secondary and Occasional Species

Populus tremuloides, *Salix arbusculoides*, *Salix pseudomonticola*.

Shrub Layer. In height 2 to 4 feet. Density, generally dense.

Primary Species

Alnus incana, *Rubus strigosus*, *Rosa* sp., *Cornus stolonifera*, *Viburnum edule*.

Secondary and Occasional Species

Picea glauca, *Ribes oxycanthoides*.

Herb Layer. Up to 1 to 2 feet in height. Density, generally dense.

Primary Species

Equisetum pratense, *Calamagrostis canadensis*, *Rubus pubescens*.

Secondary Species

Picea glauca, *Mitella nuda*, *Ribes triste*, *Viola renifolia* var. *Brainerdii*, *Aralia nudicaulis*, *Cornus canadensis*, *Mertensia paniculata*, *Galium boreale*.

Bryophyte and Lichen Layer. Absent.

(In addition to the Liard River recent floodplains, there also exist similar small areas along tributary streams. These, however, have not been considered of sufficient importance to merit separate treatment.)

ANNOTATED LIST OF PLANTS COLLECTED

The list which follows comprises 354 entities, consisting of 34 lichens, 41 bryophytes, and 279 vascular plants. The original collection was of 684 numbers. A first set of the specimens collected has been deposited in the National Herbarium of Canada.

For each species, collection numbers are cited following a brief statement of topography and vegetation where collected. Where a plant represented a new record for the Mackenzie District, N.W.T., it has been labelled "Addition to Mackenzie Flora." A brief note outlines the distribution and abundance of each plant within the study area. Where it is stated that a plant was noted in a certain number of stations, this number of stations refers to its occurrence in the 200 cover-abundance station records made by the writer and described earlier. Phenological data are not voluminous and have been taken from the specimens collected.

In addition to the plants collected within the study area, a collection of 15 specimens was made at Virginia Falls on South Nahanni River.

Of these, only *Arctagrostis angustifolia*, *Calamagrostis neglecta*, *Carex membranacea*, *Cypripedium passerinum*, and *Tofieldia pusilla* were unique to this collection location.

Of the total of 354 taxa collected, 29, according to Dr. Porsild and Dr. Crum, are "first" records for the flora of the Mackenzie District:

Usnea caucasica, *Dicranum drummondii*, *Dicranum fragilifolium*, *Entodon cladorrhizans*, *Pteritis nodulosa*, *Athyrium Filix-femina*, *Glyceria striata* var. *stricta*, *Carex Bebbii*, *Carex festivella*, *Carex retrorsa*, *Luzula multiflora* ssp. *frigida*, *Streptopus amplexifolius*, *Listera cordata*, *Salix MacCalliana*, *Ranunculus septentrionalis*, *Thalictrum sparsiflorum*, *Cardamine pensylvanica*, *Sorbus scopulina*, *Oxytropis varians*, *Impatiens biflora*, *Viola rugulosa*, *Circaea alpina*, *Aralia nudicaulis*, *Vaccinium caespitosum*, *Vaccinium membranaceum*, *Galium labradoricum*, *Galium triflorum*, *Adoxa Moschatellina*, and *Aster praealtus*.

The following 12 taxa, although previously recorded from the Mackenzie District, according to Dr. Porsild, constitute significant extensions of their known ranges: *Usnea lapponica*, *Lycopodium obscurum* var. *dendroideum*, *Pinus contorta* var. *latifolia*, *Arctophila fulva*, *Carex membranacea*, *Carex Williamsii*, *Juncus biglumis*, *Spiraea Beauverdiana*, *Geranium Bicknellii*, *Gentiana prostrata*, *Arnica cordifolia*, and *Senecio triangularis*.

The phytogeographic significance and evaluation of the more important range extensions resulting from my collection will be fully discussed by Dr. Porsild in a forthcoming paper on the flora of the Mackenzie District. As pointed out by him (in litt.) the presence in the Liard River area of a number of Pacific Coast species must be attributed to the "Liard Gap," which he considers an important migration route.

LICHENS

PELTIGERACEAE

Peltigera aphthosa (L.) Willd.

Liard River, white spruce forest, No. 38, 526; balsam poplar forest, on dead wood, No. 512. Common; noted on 47 stations, well distributed throughout the area. Very often found on dead wood.

CLADONIACEAE

Cladonia alpestris (L.) Rabenh.

Mackenzie Lowlands, black spruce forest, No. 302. Liard Range, 2,500 feet, alpine fir-white spruce forest, No. 346. Liard River, black spruce forest, No. 538, 576. Noted on 11 stations, largely in black spruce forest of floodplains, terraces, and Mackenzie Lowlands, though noted also in white spruce forest of the Liard Range.

Cladonia amaurocraea (Flk.) Schaer.

Liard Range, timberline forest, 3,800 feet, No. 463. Sole collection.

Cladonia cornuta (L.) Hoffm.

Liard Range, 2,500 feet, alpine fir-white spruce forest, No. 361. Sole occurrence noted.

Cladonia gracilis var. *dilatata* Hoffm.

Liard Range, 2,500 feet, alpine fir-white spruce forest, No. 361. Sole occurrence noted.

Cladonia gracilis var. *dilatata* fo. *dilacerata* (Flk.) Vainio

Liard River, balsam poplar forest, on dead wood, No. 514. Sole collection.

Cladonia macilenta fo. *styracella* (Ach.) Vainio

Nahanni Butte, alpine tundra, 4,300 feet, No. 655. Sole collection.

Cladonia mitis Sandst.

Liard Range, 2,000 feet, lodgepole pine forest, No. 434. Sole occurrence noted.

Cladonia rangiferina (L.) Web.

Liard River, black spruce forest, No. 72, 539. Noted on nine stations, all in floodplains or terraces, mostly in black spruce forest, though occasionally on dead wood in burns.

Cladonia rangiferina fo. *setigera* Oxner

Mackenzie Lowlands, black spruce forest, No. 278. Sole collection.

Cladonia sylvatica (L.) Hoffm.

Liard Range, 2,300 feet, white spruce-lodgepole pine forest, No. 340. Liard Range, 3,800 feet, alpine tundra, No. 455. Fairly common in the Liard Range.

Cladonia sylvatica fo. *sphagnoides* Flk.

Liard Range, 2,500 feet, white spruce-alpine fir forest, No. 362. Sole collection.

Cladonia uncialis (L.) Web.

Liard Range, 2,000 feet, lodgepole pine forest, No. 438. Sole occurrence noted.

Stereocaulon paschale (L.) Hoffm.

Liard Range, 2,000 to 2,300 feet, lodgepole pine forest, No. 339, 437. A dominant species of lodgepole pine-lichen woodland. Confined to this forest.

PERTUSARIACEAE

Pertusaria sp.

Nahanni Butte, 4,300 feet, alpine tundra, No. 653A. Sole collection.

PARMELIACEAE

Parmelia physodes (L.) Ach.

Liard River, white spruce forest, on white spruce branches, No. 187A. Liard Range, 2,200 feet, lodgepole pine-spruce forest, on black spruce branches, No. 326; 2,600 to 2,700 feet, alpine fir forest, on alpine fir branches, No. 445B. Fairly common, especially in the Liard Range.

Parmelia sulcata Tayl.

Liard River, white birch forest, on boles of white birch, No. 138. Mackenzie Lowlands, mixedwood forest, on white spruce branches, No. 304A. Liard Range, 2,600 to 2,700 feet, alpine fir forest, on alpine fir branches, No. 445C. Fairly common throughout the area.

Cetraria cucullata (Bell) Ach.

Liard Range, 2,000 feet, lodgepole pine forest, No. 436. Liard Range, 3,800 feet, alpine tundra, No. 457, 462. Nahanni Butte, 4,300 feet, alpine tundra, No. 662. Noted only in Liard Range and Nahanni Butte in situations described above.

Cetraria islandica (L.) Ach.

Liard Range, 3,800 feet, alpine tundra, No. 458, 460. Nahanni Butte 4,300 feet, alpine tundra, No. 652C, 663. Sole situations where noted.

Cetraria nivalis (L.) Ach.

Liard Range, 2,000 feet, lodgepole pine forest, No. 435; 3,800 feet, alpine tundra, No. 456. Nahanni Butte, 4,300 feet, alpine tundra, No. 652, 663. Noted only in the Liard Range and on Nahanni Butte, with the exception of one station on terraces west of Liard River.

Cetraria pinastri (Scop.) S. Gray

Mackenzie Lowlands, old burn, on dead black spruce, No. 303. Liard Range, 2,600 to 2,700 feet, alpine fir forest, on alpine fir branches, No. 445D. Sole situations where noted.

Cetraria saepincola (Ehrh.) Ach.

Liard Range, 2,600 to 2,700 feet, alpine fir forest, on alpine fir branches, No. 445D. Sole occurrence noted.

Cetraria Tilesii Ach.

Liard Range, 3,800 feet, tundra, No. 461. Nahanni Butte, 4,300 feet, alpine tundra, No. 653. Occasional in tundra.

USNEACEAE

Evernia mesomorpha Nyl.

Liard River, white birch forest, on boles of white birch, No. 138A; white spruce forest, on white spruce branches, No. 187C. Fairly common in floodplains forest, in association with *Parmelia* species.

Dactylina arctica (Hook.) Nyl.

Liard Range, 3,800 feet, alpine tundra, No. 459. Sole occurrence noted.

Alectoria jubata (L.) Ach.

Liard Range, lodgepole pine-spruce forest, 2,300 feet, on branches of black and white spruce, No. 326, 326A. Liard Range, alpine fir forest, 2,600 to 2,700 feet, on alpine fir branches, No. 445A. Fairly common on branches of spruces and alpine fir at middle elevations of the Liard Range.

Alectoria nigricans (Ach.) Nyl.

Nahanni Butte, 4,300 feet, alpine tundra, No. 652B. Sole occurrence noted.

Alectoria ochroleuca (Hoffm.) Mass.

Liard Range, 3,800 feet, alpine tundra, No. 453. Nahanni Butte, 4,300 feet, alpine tundra, No. 652A, 663. Sole situations where noted.

Usnea caucasica Vainio

Liard Range, 2,300 to 2,400 feet, lodgepole pine-white spruce forest, on lodgepole pine branches, No. 332; 2,600 to 2,700 feet, alpine fir forest, on

alpine fir branches, No. 445. Addition to Mackenzie flora. Possibly first North American collection. Sole collections but appeared to be fairly common in the Liard Range.

Usnea cavernosa Tuck.

Liard River, white spruce forest, No. 94. Common in the recent floodplains white spruce forest.

Usnea lapponica Vainio

Liard Range, 2,300 to 2,400 feet, lodgepole pine forest, on lodgepole pine branches, No. 326A. Sole collection but may be fairly common in the Liard Range.

Usnea sorediifera (Hue) Motyka

Mackenzie Lowlands, mixedwood forest, on white spruce branches, No. 304. Sole collection.

PHYSIACEAE

Physcia grisea (Lam.) Zahl.

Liard River, white spruce forest, on white spruce branches, No. 187B. Sole collection.

Physcia orbicularis (Neck.) Poetsch.

Liard River, white spruce forest, on white spruce branches, No. 187B. Sole collection.

BRYOPHYTES

SPHAGNACEAE

Sphagnum magellanicum Brid.

Liard River, black spruce forest, No. 75, 608. Noted only on two black spruce forest stations of the older floodplains.

Sphagnum recurvum P-B.

Liard River, black spruce forest, No. 76, 604. Noted only in two black spruce forest stations of the older floodplains.

Sphagnum teres (Schimp.) Ångstr.

Liard River, black spruce forest, No. 605. Sole occurrence noted.

Sphagnum warnstorffianum DuRietz

Liard River, black spruce forest, No. 74, 606, 607. Mackenzie Lowlands, black spruce forest, No. 276. The most common *Sphagnum* species in the area; noted on seven stations, of which two were black spruce forest stations of the Mackenzie Lowlands, and the others black spruce forest stations of the older floodplains.

DITRICHACEAE

Ditrichum flexicaule (Schwaegr.) Hampe.

Nahanni Butte, 4,300 feet, alpine tundra, No. 653. Sole occurrence noted.

Ceratodon purpureus (Hedw.) Brid.

Liard River, balsam poplar forest, on dead wood, No. 515. Nahanni Butte, 4,300 feet, alpine tundra, No. 656. Sole stations where noted.

DICRANACEAE

Dicranum bergeri Bland.

Flett Creek, black spruce forest, No. 540. Noted twice, in both cases black spruce forest in Flett Creek area.

Dicranum drummondii C.M.

Liard Range, 2,500 feet, white spruce-alpine fir forest, No. 353. Addition to Mackenzie flora. Noted on six stations, each in forest of the Liard Range.

Dicranum fragilifolium Lindb.

Liard River, white spruce forest, No. 23, 232, 308; black spruce forest, No. 577. Addition to Mackenzie flora. Noted on nine stations, of which six were in terrace forest on both east and west shores of Liard River. Otherwise noted in the older floodplains. Never abundant.

Dicranum fuscescens Turn.

Liard River, white spruce forest, No. 307. Liard Range, 3,800 feet, alpine fir forest, No. 467. Nahanni Butte, summit, 4,300 feet, No. 661. Noted only in the above situations.

Dicranum muehlenbeckii BSG.

Liard River, white spruce forest, No. 88. Mackenzie Lowlands, black spruce forest, No. 301. Noted only in the above situations.

Dicranum rugosum Brid.

Mackenzie Lowlands, depressional shrub, No. 153. Liard River, white spruce forest, No. 305; black spruce forest, No. 575. Noted on six stations, five of these in white spruce and black spruce forest of terraces and older floodplains.

BRYACEAE

Pohlia nutans (Hedw.) Lindb.

Liard River, balsam poplar forest, on dead wood, No. 514. Sole occurrence noted.

Leptobryum pyriforme (Hedw.) Schimp.

Liard River, old burn, No. 177A. Sole occurrence noted.

MNIACEAE

Mnium affine Bland.

Liard River, mixedwood forest, No. 7; edge of meadow, No. 26. Mackenzie Lowlands, moist depression, No. 154. Noted on 21 stations. Appeared to prefer moist situations, hence was frequently found in shrubby depressions and in white spruce forest of the recent floodplains. Noted once in the Liard Range between 2,500 and 3,000 feet.

AULACOMNIACEAE

Aulacomnium palustre (Hedw.) Schwaegr.

Liard River, old burn, on dead wood, No. 133, 563, 615, 616. Mackenzie Lowlands, black spruce forest, No. 273. Liard Range, alpine tundra, 3,800 feet, No. 452. Liard River, balsam poplar forest, on dead wood, No. 513; black spruce forest, No. 574, 605, 610; white spruce forest, No. 620. Noted on 15 stations, never abundant. Most common in black spruce forest of the Mackenzie Lowlands and of the terraces and floodplains. Noted once in alpine tundra of Liard Range. On several occasions found on dead wood in burns on the floodplains.

Aulacomnium turgidum (Wahl.) Schwaegr.

Liard Range, alpine tundra, 3,800 feet, No. 451. Nahanni Butte, alpine tundra, 4,300 feet, No. 660. Sole situations where noted.

TIMMIACEAE

Timmia bavarica Hessel.

Liard River, white spruce forest, No. 488. Noted on five forest stations of the older floodplains.

ORTHOTRICHACEAE

Orthotrichum speciosum Nees

Liard River, white spruce forest, tree bole, No. 187. Fairly common on white spruce boles and branches, in association with *Parmelia physodes*, *Evernia mesomorpha*, *Physcia grisea*, and *P. orbicularis*.

CLIMACIACEAE

Climacium dendroides (Hedw.) Web. & Mohr

Liard River, moist depression, No. 21. Mackenzie Lowlands, moist depression, No. 274. Sole stations where noted.

THUIDIACEAE

Abietinella abietina (Hedw.) C.M.

Liard Range, 3,800 feet, alpine fir forest, No. 418. Sole station where noted.

HYPNACEAE

Calliergon giganteum (Schimp.) Kindb.

Mackenzie Lowlands, black spruce forest, No. 264. Noted only in two stations, as above.

Tomenthypnum nitens (Hedw.) Loeske

Mackenzie Lowlands, black spruce forest, No. 277. Flett Creek, black spruce forest, No. 537. Liard River, black spruce forest, No. 596; old burn, No. 185. Noted on 11 stations, of which five were in black spruce forest of the Mackenzie Lowlands, two were in black spruce terrace forest, and the

others, in black spruce forest of the older floodplains. A dominant species in some black spruce forest stations.

Brachythecium salebrosum (Web. & Mohr) BSG.

Liard Range, 2,300 feet, lodgepole pine forest, No. 356. Liard River, balsam poplar forest, on dead wood, No. 516. Sole stations where noted.

Eurhynchium pulchellum (Hedw.) Jenn.

Liard River, white spruce forest, No. 17, 158, 184, 185. Common, though never abundant, in the floodplains forest especially on white spruce root buttresses.

Entodon cladorrhizans (Hedw.) C.M.

Liard River, white spruce forest, No. 186, 489. Addition to Mackenzie flora. Noted only in the above situation.

Pleurozium schreberi (Brid.) Mitt.

Liard River, white spruce forest, No. 33, 41, 528; black spruce forest, No. 73, 572. Mackenzie Lowlands, black spruce forest, No. 143, 298, 299, 309. Liard Range, 2,500 to 3,800 feet, No. 448, 464. Flett Creek, black spruce forest, No. 542. Common, noted on 80 stations, variable in abundance though often a dominant species of spruce forest.

Campylium hispidulum (Brid.) Mitt.

Liard River, old burn, on dead wood, No. 177A. Liard Range, 2,300 feet, lodgepole pine forest, No. 356. Sole stations where noted.

Drepanocladus uncinatus (Hedw.) Warnst.

Liard Range, 2,500 feet, lodgepole pine forest, No. 356. Liard River, white spruce-balsam poplar forest, No. 487; balsam poplar forest, on dead wood, No. 512, 514. Fairly common though never abundant, generally on dead wood.

Pylaisia polyantha (Hedw.) BSG.

Liard River, old burn, No. 177; balsam poplar forest, on boles of trees, No. 183. Common on boles of balsam poplar throughout the area.

Hypnum cupressiforme Hedw.

Nahanni Butte, alpine tundra, 4,300 feet, No. 653. Sole occurrence noted.

Ptilium crista-castrensis (Hedw.) DeNot.

Liard River, white spruce forest, No. 12, 43, 530. Mackenzie Lowlands, black spruce forest, No. 142, 300, 311. Liard Range, 2,500 to 3,800 feet, No. 446, 465. Liard River, balsam poplar forest, on dead wood, No. 514. Common; noted on 68 stations, though seldom dominant. Found throughout the area.

Rhytidium rugosum (Hedw.) Kindb.

Nahanni Butte, summit, 4,300 feet, No. 660A. Sole occurrence noted.

Rhytidiadelphus triquetrus (Hedw.) Warnst.

Liard River, white spruce forest, No. 32, 61, 527. Noted on 20 stations, all in floodplain forest. Most common in white spruce forest in the recent floodplains.

Hylocomium splendens (Hedw.) BSG.

Liard River, white spruce forest, No. 13, 42, 306, 529; black spruce forest, No. 541, 551, 573, 578. Mackenzie Lowlands, black spruce forest, No. 144, 275, 310. Liard Range, 2,300 to 3,800 feet, No. 323, 354, 447, 454, 465, 466. Nahanni Butte, 4,300 feet, No. 659, 660. Very common throughout the area. A dominant species, noted on 110 stations.

POLYTRICHACEAE

Polytrichum commune Hedw.

Liard Range, 2,500 feet, white spruce-alpine fir forest, No. 359. Noted only in the Liard Range.

Polytrichum juniperinum Hedw.

Mackenzie Lowlands, black spruce forest, No. 141; old burn, No. 284. Liard River, white spruce-trembling aspen forest, No. 226. Liard Range, 2,500 to 3,800 feet, white spruce-alpine fir forest, No. 352, 420; 2,500 to 3,800 feet, lodgepole pine forest, No. 355. Nahanni Butte, alpine tundra, 4,300 feet, No. 654, 656, 657. Noted on 16 stations, half of these in the Liard Range. Never abundant.

Polytrichum juniperinum var. *alpestre* (Hoppe) BSG.

Liard River, black spruce forest, No. 609. Sole collection.

Polytrichum piliferum Hedw.

Liard Range, 2,500 feet, lodgepole pine forest, No. 322. Sole occurrence noted.

PTILIDIACEAE

Ptilidium ciliare (L.) Nees

Liard Range, 2,500 feet, white spruce-alpine fir forest, No. 350. Noted on only four stations, two in forest of the Liard Range, two in terrace forest.

MARCHANTIACEAE

Preissia quadrata (Scop.) Nees

Liard River, muddy shore, No. 520. Sole occurrence noted.

VASCULAR PLANTS

POLYPODIACEAE

Cystopteris fragilis (L.) Bernh.

Nahanni Butte, 4,300 feet, alpine tundra, No. 632. Sole occurrence noted.

Pteritis nodulosa (Michx.) Nieuwl.

Recent floodplains, depressional shrub, No. 34, 37. Addition to Mackenzie flora. Abundant in some moist depressions of the recent floodplains.

Athyrium Filix-femina (L.) Roth.

Fort Liard, older floodplains, seismic line, No. 206. Addition to Mackenzie flora. Sole occurrence noted.

EQUISETACEAE

Equisetum arvense L.

Terraces, white spruce forest, No. 58. Mackenzie Lowlands, black spruce forest, No. 146. Flett Creek, terraces, aspen forest, No. 557; white spruce forest, No. 560. Common throughout the area. On recent floodplains common in frequently flooded habitats. Common and abundant in terrace forests and also in the Mackenzie Lowlands, especially in black spruce forests.

Equisetum hiemale L. var. *californicum* Milde

Liard River, silt bar, No. 2. Very common in frequently flooded habitats. Found in riparian shrub and a frequent and dominant component of some balsam poplar forests. Entirely confined to recent floodplains.

Equisetum limosum L.

Fort Liard, older floodplains, flooded depression, No. 224. Liard River, older floodplains, black spruce forest, No. 603. Sole occurrences noted. In the first, it formed a pure stand covering 60 per cent of the ground surface. In the second, it occurred as occasional stems in wet black spruce forest.

Equisetum palustre L.

Liard River, silt bar, No. 3. Common on mud bars on Liard River and occasional in riparian shrub in company with *E. heimale* var. *californicum*.

Equisetum pratense Ehrh.

Terrace, white spruce forest, No. 60. Mackenzie Lowlands, black spruce forest, No. 145, 285. Liard Range, timberline, 3,800 feet, No. 414. Flett Creek, aspen forest, No. 552, 553. Best represented on the recent floodplains. A dominant species of white spruce and balsam poplar forests. An occasional species in some forests of the Liard Range and Mackenzie Lowlands.

Equisetum scirpoides Michx.

Terraces, mixedwood forest, No. 15. A common species in forest types containing spruce.

Equisetum sylvaticum L. var. *pauciramosum* Milde

Terraces, mixedwood forest, No. 6, 52. An occasional species of moist depressions in fairly open forest. Not noted in the recent floodplains and rare in the Liard Range.

LYCOPODIACEAE

Lycopodium annotinum L.

Liard Range, lodgepole pine forest, 2,500 feet, No. 357. Confined to the Liard Range where it was a common, though rarely an abundant, species.

Lycopodium annotinum L. var. *alpestre* Hartm.

Terraces, mixedwood forest, No. 56. Occasional in mixedwood terrace forests and in the Mackenzie Lowlands.

Lycopodium clavatum L.

Liard Range, 2,500 feet, mixed forest, No. 348. Apparently confined to the Liard Range. A relatively rare forest species.

Lycopodium complanatum L.

Terraces, mixedwood forest, 1,500 feet, No. 51. Almost entirely confined to the area west of Liard River, though once noted in the Mackenzie Lowlands. Preferred middle and higher altitudes. Fairly common in the Liard Range. Found also on the summit of Nahanni Butte. Immature strobils, July 3.

Lycopodium obscurum L. var. *dendroideum* (Michx.) D.E. Eat.

Liard Range, 2,500 feet, mixed forest, No. 360. Second record for Mackenzie District. Found only in the Liard Range where it was an occasional species in white spruce and lodgepole pine forests at 2,000 to 2,500 feet. Well-formed strobils, July 25.

Lycopodium Selago L.

Nahanni Butte, alpine tundra, 4,300 feet, No. 623. Sole occurrence noted.

PINACEAE

Pinus Banksiana Lamb.

Nahanni Butte, 2,000 feet, south-facing slope, as pure forest, No. 684. Noted on a total of six stations, two in the Mackenzie Lowlands, two on older floodplains, one on terraces, and one on Nahanni Butte. Only in the last named did it form a pure stand. Otherwise it was an occasional component of mixed stands.

Pinus contorta Loud. var. *latifolia* Engelm.

Liard Range, 2,500 feet, No. 439; 3,600 feet, No. 440, 444. Nahanni Butte south-facing slope, 3,500 feet, No. 668. Second record from Mackenzie District. Confined to the Liard Range, and Nahanni Butte, at elevations over 1,800 feet. In the Liard Range it formed pure stands in some cases and occurred in mixture with *Picea glauca*, *Picea mariana*, and *Abies lasiocarpa*.

Larix laricina (Du Roi) K. Koch

Mackenzie Lowlands, 1,600 feet, in admixture with black spruce, No. 248, 270. Liard Range, 3,700 feet, at timberline, No. 443. Virginia Falls,

South Nahanni River, No. 468. Most commonly a concomitant species of black spruce forest in floodplains, terraces, and Mackenzie Lowlands. Never abundant. Also occasionally found in brûlé in the floodplains. Occasional at timberline in the Liard Range. Noted on a total of 14 stations. Flowers and immature fruit July 20.

Picea glauca (Moench) Voss

Kotaneeclee River, No. 93. Liard Range, No. 349. Practically ubiquitous in the area. Noted on a total of 140 stations.

Picea glauca (Moench) Voss var. *albertiana* (S. Brown) Sarg.

Nahanni Butte, rocky slope, 3,500 feet, No. 667. Sole occurrence positively identified. No specimens typically resembling *P. glauca* var. *Porsildii* were seen.

Picea mariana (Mill.) BSP.

Mackenzie Lowlands, No. 147, 296. Liard Range, 3,700 feet, alpine fir forest, No. 441. Noted everywhere, save on Nahanni Butte. Best developed on older floodplains surfaces and in the Mackenzie Lowlands. Found growing under a wide range of habitat conditions.

Abies lasiocarpa (Hook.) Nutt.

Mackenzie Lowlands, 1,700 feet, brûlé, No. 290 (seedling). Terraces, 1,300 feet, mixed broadleaved forest, No. 295. Older floodplains, mixedwood forest, No. 40. Terraces, mixedwood forest, No. 62, 140. Liard Range, 2,500 to 3,700 feet, No. 338, 442, 449, 450. As a mature tree common in the Liard Range where it formed almost pure forests from 2,600 to 3,800 feet on the east slope. On terraces west of Liard River it occurred once as a mature tree in sparse mixture with white spruce above 1,500 feet. As a prostrate or semi-prostrate shrub found on terraces east of Liard River and in the Mackenzie Lowlands.

Juniperus communis L.

Older floodplains, mixedwood forest, No. 19. Liard Range, alpine tundra, 3,800 feet, No. 404. An occasional species noted only on four stations. Never abundant. Immature fruits July 1.

Juniperus communis L. var. *montana* Ait.

Near Nahanni Butte, white spruce forest, older floodplains, No. 619. Nahanni Butte, rocky slope, 4,100 feet, No. 664A. Confined to Nahanni Butte at high elevations, excepting the stations where No. 619 was collected. Never abundant. Immature fruits August 22.

Juniperus horizontalis Moench

Nahanni Butte, rocky slope, 3,500 feet, No. 664, 665, 665A. Confined to Nahanni Butte where on the south slope it descended to river-level. Immature fruits August 22.

GRAMINEAE

Hierochloa alpina (Sw.) R. & S.

Liard Range, white spruce – lodgepole pine forest, 2,400 feet, No. 342; 3,800 feet, alpine tundra, No. 363, 396. Occasional in alpine tundra. Infrequent in open mountain forest. Immature fruits July 25.

Alopecurus aequalis Sobol.

Kotanelee River, sandbar, No. 103. Occasional on sandbars in southern part of area.

Arctagrostis arundinacea (Trin.) Beal

Fisherman Lake, No. 427. Flett Creek, black spruce forest, No. 550. Liard River, white spruce forest, No. 614. Occasional in black spruce forests of floodplains and terraces. Very rare in floodplain white spruce forest. Immature fruit August 20.

Arctagrostis angustifolia Nash

Virginia Falls, South Nahanni River, No. 477, 480. Sole occurrence noted.

Cinna latifolia (Trev.) Griseb.

Liard River, sandbar, No. 63. Balsam poplar forest, No. 521, 599. Confined to the recent floodplains. An occasional species of sandbars and riparian shrub, though on two stations encountered in balsam poplar forest. Immature fruit July 4.

Agrostis scabra Willd.

Liard River, sandbar, No. 71, 166. Kotanelee River, sandbar, No. 113. Liard Range, 2,500 feet, lodgepole pine – white spruce forest, No. 341. Common on sandbars. Only occasional in open forest of Liard Range. Immature fruit July 4, 25.

Calamagrostis canadensis (Michx.) Nutt.

Older floodplains, meadow, No. 30. Sandbar, No. 116, 168; depressional shrub, No. 124, Fort Liard, brûlé, No. 174; open seismic line, No. 191. Liard Range, 2,400 feet, mixed forest, No. 327. Liard River, aspen forest, No. 484. Nahanni Butte, brûlé, No. 617. Common throughout the area. A dominant species of shrub communities in depressions of the floodplains. Often abundant in riparian shrub. Common in floodplain mesophytic forests. Occasional in the Mackenzie Lowlands. In the Liard Range in forests up to timberline. Immature fruit July 9, August 21. Mature fruit July 12.

Calamagrostis neglecta (Ehrh.) Gaertn.

Virginia Falls, South Nahanni River, No. 479. Sole occurrence noted.

Calamagrostis purpurascens R. Br.

Liard Range, alpine tundra, 3,800 feet, No. 377, 408. Nahanni Butte, alpine tundra, 4,100 feet, No. 629. Nahanni Butte, 2,500 feet, No. 678. A

fairly common species of the alpine tundra. Infrequent in forests at timberline. Immature fruit July 25, August 22.

Deschampsia caespitosa (L.) Beauv.

Liard River, No. 501. Occasional on muddy shores.

Trisetum spicatum (L.) Richt.

Liard Range, alpine tundra, 3,800 feet, No. 398A. Sole occurrence noted.

Trisetum spicatum (L.) Richt. var. *Maidenii* Fern.

Nahanni Butte, alpine tundra, 4,300 feet, No. 642, 647, 648. Sole occurrence noted.

Trisetum spicatum (L.) Richt. var. *molle* (Michx.) Beal

Kotanelee River, sandbar, No. 108. Liard Range, 3,800 feet, timberline forest, No. 417. Occasional in forests of Liard Range at timberline. Immature fruit July 9.

Beckmannia Syzigachne (Steud.) Fern.

Kotanelee River, shore, No. 99. Sole occurrence noted. Immature fruit July 7.

Poa alpigena (Fr.) Lindm.

Sandbar, No. 98, 121, 167. Fort Liard, seismic line, No. 201. Occasional on sandbars in southern part of area. Immature fruit July 7.

Poa glauca M. Vahl

Liard Range, alpine tundra, 3,800 feet, No. 398. Sole occurrence noted.

Poa interior Rydb.

Nahanni Butte, 4,300 feet, alpine tundra, No. 641, 651. Sole occurrence noted.

Poa palustris L.

Fort Liard, seismic line, No. 192. Sole occurrence noted. Immature fruit July 17.

Arctophila fulva (Trin.) Rupr.

Liard Range, timberline forest, 3,800 feet, No. 399. Southernmost record in Mackenzie drainage. Sole occurrence noted. Immature fruit July 26.

Glyceria maxima Wats.

Fort Liard, seismic line, older floodplains, No. 193. Sole occurrence noted. Immature fruit July 17.

Glyceria pulchella (Nash) K. Sch.

Fort Liard, open seismic line, No. 229. Liard River, muddy shore, No. 505. Occasional on sandbars. Immature fruit July 18.

Glyceria striata (Lam.) Hitchc. var. *stricta* (Scribn.) Fern.

Mackenzie Lowlands, open trail, No. 293. Addition to Mackenzie flora. Sole occurrence noted. Flowering July 20.

Festuca brachyphylla Schultes

Liard Range, 3,800 feet, alpine tundra, No. 398B. Occasional in alpine tundra.

Bromus Pumpellianus Scribn.

Liard Range, 3,800 feet, alpine tundra, No. 409. Nahanni Butte, alpine tundra, 4,100 feet, No. 683. Fairly common in alpine tundra. Noted also in rocky slope forest on Nahanni Butte. Immature fruit July 26, August 22.

Agropyron latiglume (Scribn. & Sm.) Rydb.

Nahanni Butte, alpine tundra, 4,300 feet, No. 642A, 650. Sole occurrence noted.

Agropyron subsecundum (Link) Hitchc.

Fort Liard, seismic line, older floodplains, No. 220, 223. Sole occurrence noted. Immature fruit July 17.

Agropyron trachycaulum (Link) Malte

Kotanelee River, sandbar, No. 118. Liard River, shingle bar, No. 161; riparian shrub, No. 568; mixedwood forest, No. 618. Common on sandbars throughout the area. Occasionally found also in open mixedwood forest at low elevations. Immature fruit July 9, August 21.

Elymus canadensis L.

Kotanelee River, sandbar, No. 119. Occasional on sandbars. Immature fruit July 9.

CYPERACEAE

Eriophorum brachyantherum Trautv.

Liard Range, alpine tundra, 3,800 feet, No. 400. Rare in alpine tundra. Mature fruit July 26.

Eleocharis palustris (L.) R. & S.

Fort Liard, channel, No. 208. Sole occurrence noted.

Eleocharis uniglumis (Link) Schultes

Liard River, muddy shore, No. 498. Sole occurrence noted.

Carex aquatilis Wahlenb.

Older floodplain, black spruce forest, No. 77, 80. Virginia Falls, South Nahanni River, No. 476. Flett Creek, No. 561. Sole stations where noted. Immature fruit July 5, August 12.

Carex atherodes Spreng.

Older floodplain, meadow, No. 24. Sole occurrence noted. Mature fruit July 1.

Carex Bebbii Olney

Fort Liard, seismic line, older floodplains, No. 212. Addition to Mackenzie flora. Sole occurrence noted. Immature fruit July 17.

Carex capillaris L.

Liard Range, 3,800 feet, alpine tundra, No. 397. Occasional in alpine tundra. Immature fruit July 26.

Carex capillaris L. var. *elongata* Olney

Flett Creek, terrace, black spruce forest, No. 548. Occasional in black spruce forest. Noted only on two stations.

Carex concinna R. Br.

Terraces, mixedwood forest, No. 69. A species of white spruce and black spruce forests, especially of the terraces. Not found on the Mackenzie Lowlands nor on the Liard Range. Noted on a total of nine stations. Immature fruit July 4.

Carex deflexa Hornem.

Liard Range, 2,400 feet, lodgepole pine-lichen woodland, No. 324. Noted only in the Liard Range, on two stations.

Carex Deweyana Schw.

Fort Liard, seismic line, No. 200, 210. Liard Range, 2,500 feet, mixed forest, No. 351. Recent floodplains, No. 598. Sole stations where noted. Immature fruit July 17.

Carex disperma Dew.

Older floodplains, meadow margin, on dead wood. No. 25. Sole occurrence noted. Immature fruit July 1.

Carex festivella Mack.

Kotanelee River, sandbar, No. 102. Addition to Mackenzie flora. Sole occurrence noted. Immature fruit July 7.

Carex membranacea Hook.

Virginia Falls, South Nahanni River, No. 474. Southernmost station in the west. Sole occurrence noted.

Carex retrorsa Schw.

Fort Liard, seismic line, No. 188. Liard River, muddy shore, No. 508. Addition to Mackenzie flora. An infrequent species of muddy shores.

Carex rostrata Stokes

Fort Liard, abandoned channel, No. 207. Virginia Falls, South Nahanni River, No. 478. Sole stations where noted.

Carex scirpoidea Michx.

Flett Creek, black spruce forest, No. 546, 547. Nahanni Butte, alpine tundra, 4,300 feet, No. 649, 658. Noted only on three stations in black spruce forest and on Nahanni Butte. Immature fruit August 11, 22.

Carex vaginata Tausch

Mackenzie Lowlands, black spruce forest, No. 257. Confined to the Mackenzie Lowlands in black spruce forest. Immature fruit July 20.

Carex Williamsii Britt.

Liard Range, 3,800 feet, alpine tundra, No. 394. Extension of range. Sole occurrence noted.

ARACEAE

Calla palustris L.

Older floodplains, wet meadow, No. 31. Sole occurrence noted. Flowering July 1.

JUNCACEAE

Juncus alpinus Vill.

Liard River, shore, No. 506. Sole occurrence noted.

Juncus balticus Willd.

Liard River, shore, No. 504. Sole occurrence noted. Flowering August 8.

Juncus biglumis L.

Liard Range, alpine tundra, 3,800 feet, No. 392, 401. Extension of range. Sole occurrence noted.

Juncus castaneus Sm.

Liard Range, alpine tundra, 3,800 feet, No. 389. Virginia Falls, South Nahanni River, No. 475. Sole stations where noted. Flowers and immature fruit July 26.

Luzula multiflora (Retz.) Lej. ssp. *frigida* (Buch.) Krecz.

Liard Range, alpine tundra, 3,800 feet, No. 393. Addition to Mackenzie flora. Sole occurrence noted.

LILIACEAE

Tofieldia coccinea Richards.

Liard Range, alpine tundra, 3,800 feet, No. 390. Occasional in alpine tundra of Liard Range. Flowering July 26.

Tofieldia occidentalis S. Wats.

Flett Creek, black spruce forest, No. 534. Sole occurrence noted. Flowering August 11.

Tofieldia pusilla (Michx.) Pers.

Virginia Falls, South Nahanni River, No. 473. Sole occurrence noted.

Zygadenus elegans Pursh

Liard Range, 3,700 feet, alpine tundra, No. 371. Flett Creek, black spruce forest, No. 544. In addition to the above, noted only on Nahanni Butte at high elevations. Flowering July 26.

Veratrum Eschscholtzii A. Gray

Liard Range, 3,800 feet, moist valley, No. 419. Sole occurrence noted.

Smilacina trifoliata (L.) Desf.

Liard River, black spruce forest, No. 85, 593, 595. Mackenzie Lowlands, depressional shrub, No. 139. Rare in the area. A species of wet black spruce forest, especially in the floodplains where it was noted on three stations. Also noted on one station in the Mackenzie Lowlands. Flowering and immature fruits July 5.

Maianthemum canadense Desf.

Fort Liard, white spruce forest, No. 178. Positively identified on only two stations, the second depressional shrub of the Mackenzie Lowlands.

Maianthemum canadense Desf. var. *interius* Fern.

Liard River, white spruce forest, No. 18. A common species, noted on 32 stations. Most abundant in the Liard Range where it occurred up to timberline. Found also in white spruce and trembling aspen forest of floodplains and terraces. Noted only once in white spruce—balsam poplar forest.

Streptopus amplexifolius (L.) DC.

Older floodplains, wet hollow, No. 47. Addition to Mackenzie flora. Rare in the area. Noted on only one other station, white spruce forest on juvenile soil near Kotaneelee River.

ORCHIDACEAE

Cypripedium passerinum Richards.

Virginia Falls, South Nahanni River, No. 481. Sole occurrence noted.

Habenaria hyperborea (L.) R. Br.

Terraces, open trail, No. 66. Mackenzie Lowlands, brûlé, No. 251. Liard River, riparian shrub, No. 517. Relatively rare. Noted on only one station in addition to the above. Flowering July 4, 20.

Habenaria obtusata (Pursh) Richards.

Terraces, mixedwood forest, No. 59. Sole occurrence noted. Flowering July 3.

Habenaria orbiculata (Pursh) Torr.

Flett Creek, aspen forest, No. 559. Only found in Flett Creek area. Rare. Once noted in open black spruce forest. Flowering August 11.

Spiranthes Romanzoffiana Cham. & Schlecht.

Mackenzie Lowlands, 1,400 feet, brûlé, No. 286. Fisherman Lake, black spruce forest, No. 428. Confined to black spruce forest. Rare.

Listera cordata (L.) R. Br.

Liard Range, 3,800 feet, lodgepole pine forest, No. 422. Addition to Mackenzie flora. Sole occurrence noted. Flowering July 26.

Goodyera repens (L.) R. Br. var. *ophioides* Fern.

Liard River, white spruce forest, No. 16. Noted on 21 stations, all white spruce forest of floodplains and terraces, with one exception (black spruce forest in Mackenzie Lowlands). Appeared to be associated with a heavy moss cover.

Corallorhiza trifida Chat.

Liard River, white spruce forest, No. 91, 159. Entirely confined to white spruce forests where it was noted on five stations. Flowering July 5, 12.

SALICACEAE

Populus balsamifera L.

Liard River, No. 163. Very common especially on juvenile soils of the floodplains. Noted on Nahanni Butte around 3,000 feet.

Populus tremuloides Michx.

A common tree species. Well distributed throughout the area. In the mountains ascended to 2,300 feet.

Salix arbusculoides Anderss.

Mackenzie Lowlands, black spruce forest, No. 292. Liard River, brûlé, No. 532; white spruce forest, No. 564. Nahanni Butte, 4,300 feet, alpine tundra, No. 633, 635, 643 (seedlings). Noted on seven stations. Most often on recent floodplains in burns and in shrub cover.

Salix Barclayi Anderss.

Fort Liard, white spruce forest, No. 129. Liard Range, lodgepole pine forest, No. 329. Common in the area, especially in burns and in shrub cover types. Well represented in the Liard Range up to timberline. Also found in white spruce and trembling aspen forests of the floodplains.

Salix Bebbiana Sarg.

Burned terrace, No. 65. Older floodplains, mixed broadleaved forest, No. 104, 485. Liard Range, 3,800 feet, timberline forest, No. 411. Liard River, No. 531, 571, 585; brûlé, No. 564A, 600. Noted on 40 stations, predominantly white spruce and aspen forest of floodplains and terraces. Rare in Liard Range. Common in burns. Occasional in black spruce forest. Flowering July 7.

Salix glauca L.

Nahanni Butte, rocky slope, 3,500 feet, No. 666. Sole occurrence noted. Mature fruit August 22.

Salix glauca L. var. *Aliceae* Ball

Liard Range, alpine tundra, No. 369. Virginia Falls, South Nahanni River, No. 470, 472A. Sole stations where noted.

Salix interior Rowlee var. *pedicellata* (Anderss.) Ball

Liard River, riparian shrub, No. 5, 162, 518, 567. Confined to new fluvial deposits. Very common as a colonizing species. Immature fruit June 30.

Salix lasiandra Benth. var. *recompens* Raup

Liard River, riparian shrub, No. 4, 519. Very common in riparian situations of Liard River. Apparently the first *Salix* species to colonize new alluvium. Confined to this situation. Immature fruit July 12.

Salix MacCalliana Rowlee

Mackenzie Lowlands, black spruce forest, No. 271. Addition to Mackenzie flora. Sole occurrence noted.

Salix mackenzieana Barr.

Liard River, black spruce forest, No. 602. Sole occurrence noted.

Salix myrtillofolia Anderss.

Mackenzie Lowlands, black spruce forest, No. 259, 282, 291. Flett Creek, black spruce forest, No. 549. A fairly common species, confined to black spruce forest.

Salix pedicellaris Pursh var. *hypoglauca* Fern.

Liard River, black spruce forest, No. 81, 613, 588. A fairly common species, confined to wet black spruce forest of the floodplains. Not noted in the Mackenzie Lowlands.

Salix planifolia Pursh

Older floodplains, meadow margin, No. 27. Apparently a rather rare species; noted only on two stations.

Salix pseudomonticola Ball

Liard River, brûlé, No. 533; new deposition, No. 566. Relatively uncommon, since noted on only four stations, of which three were in recent floodplains. The fourth was aspen forest along Flett Creek.

Salix reticulata L.

Liard Range, alpine tundra, 3,800 feet, No. 387. Sole occurrence noted.

Salix Scouleriana Barr.

Black spruce forest, No. 262, 263; open trail, No. 297. Liard Range, 2,500 feet, white spruce forest, No. 344. Terraces, aspen forest, No. 495, 497. Totally absent from the floodplain but common and abundant in the Mackenzie Lowlands and occasional in the Liard Range. Noted once in terrace forest.

BETULACEAE

Betula glandulosa Michx.

Mackenzie Lowlands, black spruce forest, No. 249. Liard Range, 3,800 feet, brûlé, No. 405. A common species, occasional in black spruce forests of the floodplains. Common in the Mackenzie Lowlands and at high elevations of the Liard Range and Nahanni Butte.

Betula papyrifera Marsh s. lat.

Liard River, aspen forest, No. 486; white spruce forest, No. 509, 510, 523, 570. Terraces, birch forest, No. 579. Nahanni Butte, alpine tundra, 4,300 feet, No. 634. Common in forests throughout the area.

Betula papyrifera Marsh var. *commutata* (Regel) Fern.

Fort Liard, older floodplains, No. 225, 228. Older floodplains, aspen forest, No. 496. Recent floodplains, white spruce forest, No. 522, 525. These were the only positively identified occurrences of var. *commutata*.

Betula papyrifera Marsh var. *neoalaskana* (Sarg.) Raup

Older floodplains, brûlé, No. 130, 131, 182. Mackenzie Lowlands, 1,600 feet, mixedwood forest, No. 253. These were the only positively identified occurrences of var. *neoalaskana*. Immature fruit July 20.

Betula pumila L. var. *glandulifera* Regel

Older floodplains, black spruce forest, No. 82. Sole occurrence noted though probably much more common than this would indicate.

Alnus crispa (Ait.) Pursh

Older floodplains, mixedwood forest, No. 9. A very common forest species noted on 68 stations. A distinct separation between *A. crispa* and *A. incana* occurred in the recent floodplains, with *A. crispa* very infrequent on juvenile soils and then only at very low density. Common in the Mackenzie Lowlands and the Liard Range. Mature fruit June 30.

Alnus incana (L.) Moench

Balsam poplar forest, No. 92. A very common species of the floodplains where it attained its greatest abundance on juvenile soils. An occasional and sparse species of the older floodplains and terraces. Occasional in moist depressions of the Mackenzie Lowlands. Not seen in the Liard Range. Noted on a total of 93 stations. Immature fruit July 6.

URTICACEAE

Urtica gracilis Ait.

Muddy shore, No. 490. Most often found in man-made clearings and on muddy shores.

SANTALACEAE

Geocaulon lividum (Richards.) Fern.

Liard River, white spruce forest, No. 70. Liard Range, 2,400 feet, lodgepole pine-white spruce forest, No. 333. Virginia Falls, South Nahanni River, No. 469. Noted on 18 stations, all white spruce and black spruce forest. Not common on the floodplains but better represented on terraces and Mackenzie Lowlands. Immature fruit July 4. Mature fruit July 26.

POLYGONACEAE

Polygonum viviparum L.

Liard Range, alpine tundra, 3,800 feet, No. 375, 388. Nahanni Butte, alpine tundra, 4,300 feet, No. 636. Common and abundant in alpine tundra. Immature fruit July 26.

CHENOPODIACEAE

Chenopodium capitatum (L.) Aschers

Kotanelee River, sandbar, No. 117. Fort Liard, cutbank, No. 173; seismic line, No. 227. Common on silty cutbanks, sandbars, muddy shores, artificial clearings, and other disturbed conditions. Mature fruit July 18.

CARYOPHYLLACEAE

Stellaria calycantha (Ledeb.) Bong.

Fisherman Lake, creek shore, No. 430. Sole occurrence noted.

Stellaria longifolia Muhl.

Fort Liard, seismic line, No. 198A. Sole occurrence noted.

Cerastium Beeringianum Cham. & Schlecht.

Nahanni Butte, alpine tundra, 4,300 feet, No. 646. Sole occurrence noted.

Arenaria lateriflora L.

Terraces, birch forest, No. 137. Sole occurrence noted. Flowering July 10.

Silene acaulis L. var. *subacaulescens* (Williams) Fern.

Nahanni Butte, 4,300 feet, alpine tundra, No. 625. Sole occurrence noted.

RANUNCULACEAE

Actaea rubra (Ait.) Willd.

Terraces, mixedwood forest, No. 50. Noted on 13 stations, all in floodplains and terraces forest. Immature fruit July 3.

Aquilegia brevistyla Hook.

Fort Liard, seismic line, No. 195. Sole occurrence noted. Flowering July 17.

Delphinium glaucum S. Wats.

Terraces, 1,500 feet, mixedwood forest, No. 46. Liard River, white spruce forest, No. 123. Fort Liard, seismic line, No. 217; balsam poplar forest, No. 315. Liard Range, 3,800 feet, alpine tundra, No. 365. Noted on eight stations. Never abundant. In addition to above, found in black spruce forest in Mackenzie Lowlands. Flowering July 9, 25.

Aconitum delphinifolium DC.

Liard Range, alpine tundra, 3,800 feet, No. 381. Common in alpine tundra.

Pulsatilla Ludoviciana (Nutt.) Heller

Nahanni Butte, 2,500 feet, No. 681. Sole occurrence noted.

Anemone multifida Poir. var. *hudsoniana* DC.

Liard Range, alpine tundra, 3,800 feet, No. 380. Sole occurrence noted.

Anemone parviflora Michx.

Flett Creek, black spruce forest, No. 535. Nahanni Butte, alpine tundra, 4,300 feet, No. 645. Occasional in tundra. Flowering August 22.

Ranunculus Macounii Britt.

Fort Liard, seismic line, No. 194. Sole occurrence noted.

Ranunculus Purshii Richards.

Fort Liard, moist slough, No. 230. Sole occurrence noted. Flowering July 18.

Ranunculus septentrionalis Poir.

East of Fort Liard, abandoned channel, No. 240. Addition to Mackenzie flora. Sole occurrence noted.

Thalictrum sparsiflorum Turcz.

Liard River, terraces, No. 35, 261. Fort Liard, open seismic line, No. 218. Addition to Mackenzie flora. Sole occurrences noted. Flowering July 2, 20. Immature fruit July 17.

PAPAVERACEAE

Corydalis aurea Willd.

Fort Liard, seismic line, No. 247. Sole occurrence noted.

Corydalis sempervirens (L.) Pers.

Liard River, seismic line, No. 293A. Sole occurrence noted.

CRUCIFERAE

Rorippa islandica (Oed. ex Murr.) Borbàs

Fort Liard, abandoned channel, No. 236. Sole occurrence noted.

Rorippa islandica (Oed. ex Murr.) Borbàs var. *microcarpa* (Regel) Fern.

Kotanelee River, sandbar, No. 110. Sole occurrence noted. Flowering July 9.

Cardamine pensylvanica Muhl.

Fort Liard, abandoned channel, No. 237. Addition to Mackenzie flora. Sole occurrence noted.

Descurainia sophioides (Fisch.) O. E. Schulz

Fort Liard, seismic line, No. 213. Sole occurrence noted.

Arabis hirsuta (L.) Scop. ssp. *pyncocarpa* (Hopkins) Hult.

Kotanelee River, sandbar, No. 114. Sole occurrence noted. Flowering July 9.

DROSERACEAE

Drosera rotundifolia L.

Liard River, black spruce forest, No. 78. Rare, only in black spruce forest. Flowering July 5.

SAXIFRAGACEAE

Saxifraga tricuspidata Rottb.

Liard Range, 2,500 feet, rocky knoll, No. 372; alpine tundra, 3,800 feet, No. 373, 385. Nahanni Butte, summit, 4,300 feet, No. 624, 627. Common in alpine tundra. Flowering July 25.

Mitella nuda L.

Mackenzie Lowlands, depressional shrub, No. 152. Noted on 89 stations, the majority in floodplains and terraces. Occasional in the Mackenzie Lowlands. Relatively rare in the Liard Range and apparently never at high elevations there. Most abundant in white spruce forest on juvenile soils of the floodplains.

Chrysosplenium tetrandrum (Lund) Fries

Terraces, mixedwood forest, No. 44. Sole occurrence noted. Flowering July 3.

Parnassia palustris L. var. *neogaea* Fern.

Mackenzie Lowlands, seismic line, No. 294. A fairly common species, especially in disturbed areas of the Mackenzie Lowlands. Flowering July 20.

Ribes glandulosum Grauer

Terraces, mixedwood forest, 1,500 feet, No. 57. Occasional in moist shrub types of the floodplains and Mackenzie Lowlands and in moist forest of terraces and Liard Range. Never abundant. Immature fruit July 3.

Ribes hudsonianum Richards.

Meadow margin, No. 29. Mackenzie Lowlands, depressional shrub, No. 149. Fort Liard, brûlé, No. 171. Noted on 19 stations, mostly in broad-leaved forest of floodplains and terraces, though found there also in black spruce and white spruce forest and in burns. Occasional in the Mackenzie Lowlands. Apparently absent from the Liard Range. Immature fruit July 1, 16.

Ribes lacustre (Pers.) Poir.

Fort Liard, brûlé, No. 170. Rare; noted only in the floodplains. Immature fruit July 16.

Ribes oxycanthoides L.

Fort Liard, No. 172. Common species, noted on 75 stations. Occasional only in the Mackenzie Lowlands; not seen in the Liard Range. Most abundant on the floodplains, especially in white spruce forest on juvenile soils. Immature fruit July 16.

Ribes triste Pall.

Terraces, mixedwood forest, No. 233. Mackenzie Lowlands, depressional shrub, No. 287. Noted on 55 stations, mostly in floodplains and terraces. Present in white spruce forest around 2,000 feet in the Liard Range. Occasional in the Mackenzie Lowlands in shrub and in white spruce forest. Immature fruit July 20.

ROSACEAE

Spiraea Beauverdiana Schneid.

Liard Range, 2,500 feet, mixed coniferous forest, No. 347. Extension of range. Sole occurrence noted.

Sorbus scopulina Greene

Mackenzie Lowlands, 1,600 feet, mixedwood forest, No. 254. Addition to Mackenzie flora. Noted on six stations, four of these in the Liard Range, two in the Mackenzie Lowlands. Never abundant.

Amelanchier alnifolia (Nutt.) Nutt.

Balsam poplar forest, No. 89. Noted on nine stations, all at low elevations in floodplains and in one instance, on low terraces, in mixedwood forest.

Rubus acaulis Michx.

Mackenzie Lowlands, 1,500 feet, brûlé, No. 252. Liard River, black spruce forest, No. 591. Noted on only three stations; black spruce forest, in Mackenzie Lowlands and floodplains. Immature fruit July 20.

Rubus Chamaemorus L.

Liard River, black spruce forest, No. 83. Noted on six stations, all black spruce forest of Mackenzie Lowlands and floodplains. Flowering July 5.

Rubus pubescens Raf.

Common; noted on 84 stations, largely in floodplains and terraces in forests of white spruce and trembling aspen. Also found in the Mackenzie Lowlands and Liard Range forests.

Rubus strigosus Michx.

Fort Liard, brûlé, No. 128. Mackenzie Lowlands, No. 255. Noted on 27 stations. Most abundant in the floodplains, especially on juvenile soils, and on terraces west of the river. A common species of moist depressions and of mesic forest. Only once noted in the Liard Range. Flowering July 8.

Fragaria glauca (S. Wats.) Rydb.

Terraces, open trail, No. 67. Mackenzie Lowlands, mixedwood forest, No. 283. Noted on 29 stations, all at low and middle elevations. Rare in the Liard Range even at its lowest elevations. Present in the Mackenzie Lowlands, often in black spruce forest. Immature fruit July 4.

Fragaria vesca L. var. *americana* Porter

Terraces, white birch – balsam poplar forest, No. 136. Noted only on three stations, two in aspen terrace forest and one in shrub cover in the Mackenzie Lowlands. Mature fruit July 10.

Potentilla fruticosa L.

Mackenzie Lowlands, black spruce forest, No. 269. Common in black spruce forest in the Mackenzie Lowlands and floodplains. Also noted in alpine tundra on Nahanni Butte. Flowering July 20.

Potentilla Ledebouriana Porsild

Liard Range, 3,800 feet, alpine tundra, No. 379; 2,500 feet, rocky knoll, No. 433. Occasional in alpine tundra of Liard Range. Flowering July 26.

Potentilla norvegica L.

Kotaneelce River, sandbar, No. 107. Fort Liard, seismic line, No. 216, 221. Occasional on sandbars. Common around Fort Liard. Flowering, immature and mature fruit, July 17.

Potentilla palustris (L.) Scop.

Liard River, black spruce forest, No. 611. Sole occurrence noted.

Potentilla yukonensis Hult.

Liard River, muddy shore, No. 500. Occasional on muddy shores.

Geum macrophyllum Willd. ssp. *perincisum* (Rydb.) Raup

Mackenzie Lowlands, depressional shrub, No. 151. Sole occurrence noted.

Dryas Drummondii Richards.

Liard River, shingle bar, No. 96. Common on bars, especially in southern part of area. Immature fruit July 8.

Dryas integrifolia M. Vahl

Liard Range, alpine tundra, 3,800 feet, No. 374. Virginia Falls, South Nahanni River, No. 472. Nahanni Butte, alpine tundra, 4,300 feet, No. 644. Common in alpine tundra. Flowering July 26.

Rosa acicularis Lindl.

Liard River, mixedwood forest, No. 586. Wild roses were very common, having been noted in 150 stations. They were most abundant in floodplains and terraces but were also found in the Mackenzie Lowlands and the Liard Range. Because of time limitations it was not always possible to distinguish the two species.

Rosa Woodsii Lindl.

Fort Liard, white spruce forest, No. 127. *See above.* Flowering July 8.

LEGUMINOSAE

Astragalus alpinus L.

Liard River, sandbar, No. 157. Liard Range, 3,800 feet, alpine tundra, No. 384. Excepting No. 157, noted only as occasional in alpine tundra. Flowering July 12.

Astragalus americanus L.

Kotanelee River, sandbar, No. 112. Sole occurrence noted. Flowering July 9.

Astragalus tenellus Pursh

Kotanelee River, sandbar, No. 120. Occasional on sandbars in Kotanelee-Liard confluence area. Flowering July 9.

Oxytropis retrorsa Fern.

Terrace, brûlé, No. 68. Sole occurrence noted. Flowering July 4.

Oxytropis splendens Dougl.

Kotanelee River, sandbar, No. 111. Sole occurrence noted. Flowering July 9.

Oxytropis varians Rydb.

Liard Range, 3,800 feet, alpine tundra, No. 376. Addition to Mackenzie flora. Occasional in tundra of Liard Range.

Hedysarum alpinum L. var. *americanum* Michx.

Fort Liard, riparian shrub, No. 314. Liard Range, alpine tundra, 3,800 feet, No. 370. Sole stations where noted. Flowering July 25.

Hedysarum Mackenzii Richards.

Liard River, sandbar, No. 1. Nahanni Butte, 2,500 feet, brûlé, No. 674. Common on sandbars of Liard River. Flowering June 29.

Vicia americana Muhl.

Kotanelee River, sandbar, No. 101. Fort Liard, balsam poplar forest, No. 316. Flett Creek, aspen forest, No. 555. Liard River, aspen-birch forest, No. 492; brûlé, No. 583. Noted on 16 stations. Fairly common on muddy shores, in riparian shrub communities and in balsam poplar forest. Also fairly common in burns in the floodplains. Flowering July 7, 25.

Lathyrus ochroleucus Hook.

Fort Liard, seismic line, No. 219. Liard River, mixedwood forest, No. 483. Flett Creek, aspen forest, No. 556. Noted on 15 stations. Aside from its common occurrence in burns on the floodplains, this species demonstrated a marked affinity for forests containing a high proportion of trembling aspen. Flowering July 17.

GERANIACEAE

Geranium Bicknellii Britt.

Fort Liard, seismic line, No. 234. Extension of range. Sole occurrence noted. Flowering July 18.

EMPETRACEAE

Empetrum nigrum L.

Liard Range, 2,500 feet, lodgepole pine forest, No. 345. Noted on eight stations, all save one in the Liard Range above 2,000 feet, the other at the base of the Liard Range in black spruce forest. In the Liard Range largely confined to lodgepole pine forest and alpine tundra.

BALSAMINACEAE

Impatiens biflora Walt.

Terraces, wet hollow, No. 36. Addition to Mackenzie flora. Sole occurrence noted.

VIOLACEAE

Viola adunca Sm.

Nahanni Butte, 2,500 feet, brûlé, No. 676. Sole occurrence noted.

Viola renifolia Gray var. *Brainerdii* (Greene) Fern.

Depressional shrub, No. 150. Fort Liard, No. 179. Liard Range, 3,800 feet, timberline, No. 407. Flett Creek, black spruce forest, No. 543. Liard River, black spruce forest, No. 592. Common, noted on 53 stations, mostly in mixedwood and white spruce forest of floodplains and terraces, though also present in black spruce forest in floodplains and Mackenzie Lowlands. Noted only once in the Liard Range.

Viola rugulosa Greene

Fort Liard, seismic line, No. 209. Addition to Mackenzie flora. Noted only in the above area.

ELAEAGNACEAE

Shepherdia canadensis (L.) Nutt.

Terraces, mixedwood forest, No. 132. Noted on 36 stations, predominantly white spruce and trembling aspen forest of floodplains and terraces

and brûlé. Present in the Mackenzie Lowlands in black spruce forest. Not seen in the Liard Range but noted on Nahanni Butte on dry rocky slope. Mature fruit July 10.

Elaeagnus commutata Bernh.

Fort Liard, cutbank, No. 246. Common at Fort Liard on river margin.

ONAGRACEAE

Circaea alpina L.

Older floodplains, mixedwood forest, No. 20. Addition to Mackenzie flora. Fairly common in the floodplains where it was largely confined to white spruce forest on juvenile soils.

Epilobium angustifolium L.

Trapper's clearing, No. 155; brûlé, No. 175. Liard Range, 2,500 feet, lodgepole pine forest, No. 331; rocky knoll, No. 432. Liard River, aspen-birch forest, No. 584. Common, noted on 34 stations. Especially abundant in burns on floodplains, terraces, and Mackenzie Lowlands. Fairly common in the Liard Range, up to timberline. Rare on juvenile soils of the floodplains but well represented in trembling aspen forest on older soils. Flowering July 11, August 15.

Epilobium glandulosum Lehm. var. *adenocaulon* (Hausskn.) Fern.

Fort Liard, seismic line, No. 198. Sole occurrence noted. Flowering July 17.

ARALIACEAE

Aralia nudicaulis L.

Fort Liard, seismic line, No. 197. Addition to Mackenzie flora. Noted on 54 stations, all with one exception on floodplains and terraces. Noted once in white spruce forest of Mackenzie Lowlands. Absent in Liard Range. Preferred mature mixedwood forests, though once noted in brûlé. On recent floodplains found only in white spruce – birch forests.

UMBELLIFERAE

Cicuta mackenzieana Raup

Fisherman Lake, moist shore, No. 429. Sole occurrence noted.

Sium suave Walt.

Fort Liard, channel, No. 190, 242. Sole occurrence noted. Flowering July 18.

CORNACEAE

Cornus canadensis L.

No. 14. Very common; noted on 130 stations. A forest species, common and abundant in all landtypes. Flowering June 30.

Cornus stolonifera Michx.

Fort Liard, No. 126. Very common in floodplains and terraces; noted on 98 stations. Especially abundant on the juvenile soils of the floodplains. On

older floodplains soils found predominantly in forest with a high proportion of trembling aspen. Apparently absent from Liard Range and only very rarely found in moist shrub depressions of the Mackenzie Lowlands, marginal to the terraces. Flowering July 8.

PYROLACEAE

Moneses uniflora (L.) Gray

Recent floodplains, white spruce forest, No. 105. Noted on 13 stations, of which nine were in the floodplains, mostly in white spruce forest. Noted on terraces and in the Mackenzie Lowlands in white spruce and black spruce forest. Flowering July 8.

Pyrola asarifolia Michx. var. *purpurea* (Bge.) Fern.

Liard River, white spruce forest, No. 10; aspen forest, No. 320, 491. Liard Range, 2,500 feet, lodgepole pine – white spruce forest, No. 330. Common; noted on 62 stations. Though most common in balsam poplar, white spruce, and aspen forests of floodplains and terraces, also found in the Mackenzie Lowlands and the Liard Range forests. Flowering June 30, July 25.

Pyrola grandiflora Rad.

Nahanni Butte, alpine tundra, 4,300 feet, No. 626. Sole occurrence noted.

Pyrola secunda L.

Terraces, mixedwood forest, 1,500 feet, No. 49. Common; noted on 61 stations, the majority in floodplains and terraces and in Liard Range. At lower elevations it appeared to prefer forests of white spruce and to a lesser extent, trembling aspen. Uncommon in balsam poplar forest and relatively rare in the Mackenzie Lowlands. Flowering July 3.

Pyrola virens Schweigg.

Terraces, white spruce forest, No. 160. Noted on 40 stations, almost all in floodplains and terraces. In the floodplains it preferred white spruce and trembling aspen forest on older soils. Relatively rare in the Mackenzie Lowlands. None noted in the Liard Range. Flowering July 12.

ERICACEAE

Ledum decumbens (Ait.) Lodd.

Liard Range, 3,800 feet, alpine tundra, No. 395. Noted only in the alpine tundra of the Liard Range and Nahanni Butte. Occasional.

Ledum groenlandicum Oed.

Older floodplains, mixedwood forest, No. 22, 55. Liard River, black spruce forest, No. 87. Mackenzie Lowlands, black spruce forest, No. 268. Noted on 29 stations. In the floodplains occasional in white spruce forest and abundant in black spruce forest. In the Mackenzie Lowlands common and abundant in black spruce forest. In the Liard Range common in forests at

timberline. Common in black spruce forests on terraces west of Liard River. Flowering July 1, 20.

Rhododendron lapponicum (L.) Wahlenb.

Liard Range, 3,800 feet, alpine tundra, No. 382. Noted only in alpine tundra. Relatively abundant there.

Andromeda Polifolia L.

Liard River, black spruce forest, No. 79. Virginia Falls, South Nahanni River, No. 482. Noted on four stations, all black spruce forests of the older floodplains.

Chamaedaphne calyculata (L.) Moench

Liard River, black spruce forest, No. 86, 601. Sole occurrence noted. Flowering July 5.

Arctostaphylos rubra (Rehd. & Wils.) Fern.

Mackenzie Lowlands, black spruce forest, No. 267. Liard Range, 2,500 feet, rocky knoll, No. 336. Noted on 13 stations, of which eight were in black spruce forest of Mackenzie Lowlands, terraces, and floodplains and three in alpine tundra. Where noted, the species was generally moderately abundant.

Arctostaphylos Uva-ursi (L.) Spreng.

Liard Range, 2,500 feet, lodgepole pine forest, No. 343. Noted on eight stations, all but one in the Liard Range and on Nahanni Butte. In the Liard Range, noted only in lodgepole pine forest around 2,500 feet elevation. On Nahanni Butte present in alpine tundra.

Oxycoccus quadripetalus Gil.

Liard River, black spruce forest, No. 84. Noted on five stations, all black spruce forest, three on older floodplains, one on terraces and one in Mackenzie Lowlands.

Vaccinium caespitosum Michx.

Liard Range, 3,800 feet, west slope, lodgepole pine forest, No. 425. Addition to Mackenzie flora. Sole occurrence noted.

Vaccinium membranaceum Dougl.

Liard Range, west slope, 3,800 feet, lodgepole pine forest, No. 421. Addition to Mackenzie flora. Noted on some stations of the Liard Range, in alpine fir and lodgepole pine forest at middle to high elevations. Occasional.

Vaccinium uliginosum L.

Liard Range, 2,400 feet, lodgepole pine – white spruce forest, No. 335. Liard River, black spruce forest, No. 587. Virginia Falls, South Nahanni River, No. 471. Nahanni Butte, 4,300 feet, alpine tundra, No. 630. Noted on 10 stations. In the Liard Range (five stations) and Nahanni Butte (two

stations) it was common and abundant in alpine tundra. On older floodplains and terraces it was confined to black spruce forests.

Vaccinium Vitis-Idaea L. var. *minus* Lodd.

Mackenzie Lowlands, black spruce forest, No. 148. Noted on 40 stations. Especially common and abundant in the Liard Range where it occurred up to timberline. In the Mackenzie Lowlands largely confined to black spruce forests, though it was noted also in white spruce stands. In the floodplains it was confined to older soils.

GENTIANACEAE

Gentiana arctophila Griseb.

Nahanni Butte, 4,300 feet, alpine tundra, No. 628. Sole occurrence noted.

Gentiana propinqua Richards.

Liard Range, 3,800 feet, alpine tundra, No. 415. Sole occurrence noted. Flowering July 26.

Gentiana prostrata Haencke

Nahanni Butte, 4,300 feet, alpine tundra, No. 640. Second record in Mackenzie District. Sole occurrence noted.

Gentiana Raupii Porsild

Liard River, muddy shore, No. 504A. Sole occurrence noted.

APOCYNACEAE

Apocynum androsaemifolium L.

Nahanni Butte, 1,000 feet, brulé, No. 671. Sole occurrence noted.

POLEMONIACEAE

Polemonium acutiflorum Willd.

Liard Range, 3,800 feet, timberline forest, No. 406. Sole occurrence noted.

BORAGINACEAE

Mertensia paniculata (Ait.) G. Don

Terraces, mixedwood forest, No. 8. Liard Range, 3,800 feet, timberline, No. 413. Common; noted on 75 stations. Best represented in floodplains and terraces on both juvenile and older soils, in shrub and white spruce and broadleaved forests. Occasional in the Liard Range where it was noted at timberline. Occasionally found in black spruce forest in Mackenzie Lowlands, floodplains, and terraces. Flowering June 30.

LABIATAE

Dracocephalum parviflorum Nutt.

Fort Liard, seismic line, No. 243. Sole occurrence noted. Flowering July 18.

Mentha arvensis L. var. *villosa* Benth.

Fort Liard, channel, No. 211, 244. Sole occurrence noted. Flowering July 17.

Scutellaria galericulata L.

Fort Liard, seismic line, No. 231. Sole occurrence noted. Flowering July 18.

Stachys palustris L. var. *pilosa* (Nutt.) Fern.

Fort Liard, seismic line, No. 204. Sole occurrence noted. Flowering July 17.

SCROPHULARIACEAE

Veronica scutellata L.

Fort Liard, channel, No. 239. Sole occurrence noted.

Castilleja Raupii Pennell ssp. *ursina* Pennell

Liard Range, alpine tundra, 3,800 feet, No. 391. Occasional in alpine tundra of Liard Range. Flowering July 26.

Pedicularis capitata Adams

Liard Range, 3,800 feet, alpine tundra, No. 386. Occasional in alpine tundra of Liard Range and Nahanni Butte.

Pedicularis labradorica Wirsing

Mackenzie Lowlands, black spruce forest, No. 280. Liard Range, 2,400 feet, lodgepole pine forest, No. 325, 334. Noted on nine stations. Distribution very sporadic. It appeared to favour middle elevations. Flowering July 20.

Pedicularis lanata Cham. & Schlecht.

Liard Range, 3,800 feet, alpine tundra, No. 368, 402. Occasional in alpine tundra of Liard Range.

PLANTAGINACEAE

Plantago major L. var. *asiatica* (L.) Dene.

Fort Liard, seismic line, No. 189. Sole occurrence noted. Flowering July 17.

RUBIACEAE

Galium boreale L.

Fort Liard, seismic line, No. 214; aspen forest, No. 319. Mackenzie Lowlands, brûlé, No. 258, 580, 582. Flett Creek, forest, No. 536, 558. Nahanni Butte, 2,500 feet, brûlé, No. 682. Common; noted on 58 stations; it was most common in floodplains and terraces and occasional in the Mackenzie Lowlands. Not seen in the Liard Range but noted on Nahanni Butte. This species appeared to prefer forests of white spruce and trembling aspen. Flowering July 17, August 15.

Galium labradoricum Wieg.

Fort Liard, channel, No. 238. Liard River, black spruce forest, No. 612. Addition to Mackenzie flora. The above are the sole stations where this species was noted. Flowering August 16.

Galium triflorum Michx.

Terraces, birch – balsam poplar forest, No. 135. Fort Liard, white spruce forest, No. 312. Addition to Mackenzie flora. Fairly common though never abundant; noted on 30 stations, almost all in the floodplains though a few on terraces. Most common in forest and riparian shrub of recent floodplains.

CAPRIFOLIACEAE

Viburnum edule (Michx.) Raf.

Terraces, mixedwood forest, 1,500 feet, No. 53. White spruce forest, recent floodplains, No. 125. Very common; noted on 130 stations. The species reached its best development in the floodplains and terraces forests. It was less abundant in both the Liard Range and Mackenzie Lowlands. Mature fruit July 8.

Linnaea borealis L. var. *americana* (Forbes) Rehd.

No. 11. Very common; noted on 107 stations. A woodland species, especially of white spruce and aspen forests. Flowering June 30.

Lonicera glaucescens Rydb.

Liard River, balsam poplar forest, No. 90; white spruce forest, No. 180. Mackenzie Lowlands, black spruce forest, No. 260. Noted on nine stations, all forests of floodplains, terraces, or Mackenzie Lowlands. An occasional component of black spruce forest in the Mackenzie Lowlands. Flowering July 5.

Symphoricarpos occidentalis Hook.

Nahanni Butte, brûlé, 1,000 to 2,500 feet, No. 670, 673. Sole occurrence noted. Flowering and mature fruit August 22.

ADOXACEAE

Adoxa Moschatellina L.

Terraces, birch – balsam poplar forest, No. 134. Addition to Mackenzie flora. In addition to the above, noted only in one black spruce station of the Mackenzie Lowlands.

CAMPANULACEAE

Campanula aurita Greene

Nahanni Butte, 4,300 feet, alpine tundra, No. 639; 3,800 feet, alpine tundra, No. 677. Noted only on Nahanni Butte; occasional in occurrence there.

Campanula lasiocarpa Cham.

Liard Range, 3,800 feet, alpine tundra, No. 431. Extension of range. Noted only in the Liard Range; occasional in alpine tundra.

Campanula rotundifolia L.

Nahanni Butte, rocky slope, 3,800 feet, No. 679. Sole occurrence noted.

COMPOSITAE

Solidago decumbens Greene var. *oreophila* (Rydb.) Fern.

Liard Range, alpine tundra, 3,800 feet, No. 378, 412. Sole occurrence noted. Flowering July 26.

Solidago lepida DC. var. *elongata* (Nutt.) Fern.

Fort Liard, seismic line, No. 205. Kotaneelee River, sandbar, No. 100, 156. Liard River, muddy shore, No. 507. Occasional in disturbed conditions, as No. 205, and in riparian situations. Flowering July 12.

Solidago multiradiata Ait. var. *scopulorum* Gray

Liard Range, alpine tundra, 3,800 feet, No. 364. Sole occurrence noted.

Aster alpinus L. ssp. *Vierhapperi* Onne

Nahanni Butte, 2,500 feet, No. 680. Sole occurrence noted. Flowering August 22.

Aster ciliolatus Lindl.

Fort Liard, seismic line, No. 215; aspen forest, No. 318. Flett Creek, black spruce forest, No. 545. Noted on eight stations. With the exception of No. 545, confined to forests of floodplains and terraces containing a high proportion of broadleaved trees. Immature fruit July 17.

Aster falcatus Lindl.

Liard River, shingle bar, No. 511. Sole occurrence noted.

Aster praealtus Poir.

Liard River, riparian shrub, No. 565. Addition to Mackenzie flora. Sole occurrence noted. Flowering August 13.

Aster sibiricus L.

Kotaneelee River, sandbar, No. 97. Fort Liard, seismic line, No. 203; balsam poplar forest, No. 317. Liard Range, alpine tundra, 3,800 feet, No. 383. Noted on six stations, with the exception of No. 203, 383, entirely in riparian situations. Flowering July 7, 25.

Erigeron angulosus Gaud. var. *kamtschaticus* (DC.) Hara

Liard River, brûlé, No. 581. Sole occurrence noted.

Erigeron philadelphicus L.

Liard River, sandbar, No. 64, 499. Noted on four stations, all riparian. Flowering July 4.

Antennaria densifolia Porsild

Nahanni Butte, 4,300 feet, alpine tundra, No. 631. Sole occurrence noted.

Antennaria isolepis Greene

Nahanni Butte, 4,300 feet, alpine tundra, No. 622. Sole occurrence noted.

Antennaria rosea (Eat.) Greene

Liard Range, 3,800 feet, alpine tundra, No. 403. Sole occurrence noted. Immature fruit July 26.

Achillea nigrescens C.A. Mey

Kotaneelee River, sandbar, No. 109. Mackenzie Lowlands, brûlé, 1,600 feet, No. 279. Liard River, No. 502A. Noted on 13 stations. It occupied two common habitats, the first sandbars and riparian shrub of Liard and Kotaneelee rivers, the second black spruce forest of the Mackenzie Lowlands. Flowering July 9.

Achillea sibirica Ledeb.

Liard River, cutbank, No. 95. Sole occurrence noted. Immature fruit July 8.

Artemisia arctica Less.

Liard Range, 3,800 feet, timberline forest, No. 416. Noted only in the Liard Range at timberline.

Artemisia canadensis Michx.

Liard River, shingle bar, No. 164, 165. Occasional in sandbars of Liard River. Flowers and immature fruits July 12.

Artemisia frigida Willd.

Nahanni Butte, 3,000 feet, brûlé, No. 669. Sole occurrence noted.

Artemisia Tilesii Ledeb.

Terraces, moist hollow, No. 45. Sole occurrence noted.

Artemisia Tilesii Ledeb. var. *elatio*r (T. & G.) Rydb.

Kotaneelee River, sandbar, No. 115, 122. Occasional in sandbars of Liard and Kotaneelee rivers and in riparian shrub. Flowers and immature fruits July 9.

Petasites frigidus (L.) Fries

Flett Creek, No. 562. Sole occurrence noted.

Petasites palmatus (Ait.) Gray

Terraces, white spruce forest, No. 48. Fort Liard, white spruce forest, No. 181, 313; black spruce forest, No. 590. Liard Range, 2,400 feet, lodge-pole pine-white spruce forest, No. 328. Fairly common; noted on 30

stations; never abundant. Seldom found on the floodplains though present on the higher terraces. Common in black spruce forest of the Mackenzie Lowlands. Also relatively frequent in the Liard Range up to timberline.

Petasites sagittatus (Banks) Gray

Margin of meadow, No. 28. Liard River, black spruce forest, No. 589. Noted on five stations, four on the older floodplains, of which three were in black spruce forest.

Arnica cordifolia Hook.

Liard Range, west slope, 3,600 feet, lodgepole pine forest, No. 424. Second record for Mackenzie District. Sole occurrence noted.

Arnica lonchophylla Greene ssp. *genuina* Maguire

Liard Range, 3,800 feet, alpine tundra, No. 366, 367; west slope, 3,600 feet, lodgepole pine forest, No. 423. Noted only in the Liard Range; occasional in alpine tundra and at timberline. Flowering July 25.

Arnica louiseana Farr ssp. *frigida* (Mey. ex Iljin) Maguire

Liard Range, 2,400 feet, lodgepole pine - white spruce forest, No. 337. Nahanni Butte, 4,300 feet, alpine tundra, No. 637. The above represents the only stations where noted. Immature fruit August 22.

Senecio lugens Richards.

Mackenzie Lowlands, black spruce forest, No. 281. Nahanni Butte, alpine tundra, 4,300 feet, No. 638. Noted only in the situations described above. Flowering July 20 and August 22.

Senecio triangularis Hook.

Liard Range, west slope, 3,200 feet, lodgepole pine forest, No. 426. Second record for Mackenzie District. Sole occurrence noted.

Taraxacum dumetorum Greene

Liard River, white spruce forest, No. 106. Sole occurrence noted. Flowering July 8.

Lactuca pulchella (Pursh) DC.

Liard River, cutbank, No. 569. Sole occurrence noted. Flowering August 13.

Hieracium umbellatum L.

Nahanni Butte, brûlé, 2,500 feet, No. 672, 675. Sole occurrence noted. Flowering August 22.

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THE VASCULAR FLORA OF AN ALPINE VALLEY IN THE MACKENZIE MOUNTAINS, N.W.T.

By A. E. PORSILD

Among the remaining major blanks on the botanical map of Canada is the great mass of mountain ranges and plateaux separating the upper Yukon and the Mackenzie Rivers. Since the Yukon Plateau, the British and Richardson Mountains, and the western parts of the Ogilvie Mountains were never glaciated, they likely harbour very ancient floras. In the Selwyn and Mackenzie Mountains there is abundant evidence of valley glaciation, but geological as well as botanical evidence favours the view that a rich and ancient flora here survived Pleistocene glaciation above the limits of valley glaciation (Porsild, 1951). The scant botanical knowledge of this vast area is derived from a few excursions into the mountain fastness, mainly by the writer's investigation of the flora and vegetation of a transect through the Selwyn and Mackenzie mountains from Johnsons Crossing in southeast Yukon to the end of the Canol Road on the middle Mackenzie River, made possible by the construction of the Canol Road (Porsild, 1945 and 1951); by Hugh M. Raup's intensive study of the flora and vegetation of a small area adjacent to Brintnell Lake in the southern part of the Mackenzie Mountains (Raup, 1947); and by a few excursions to the easternmost spur of the Richardson Mountains west of the Mackenzie Delta (Porsild, 1943). Some additional minor collections, mainly from the perimeter of the Mackenzie Mountains, have been included in these reports or reported on separately (Cody, 1960; Jeffrey, 1961). As yet, no botanists have ever visited the Ogilvie Mountains, the British or the main ranges of the Richardson Mountains, or the Peel Plateau.

A small collection of vascular plants from a mountain valley on the upper South Nahanni River was recently presented to the National Herbarium of Canada by the collector, Mr. Edward W. Arnold, a graduate student of the University of Michigan, Ann Arbor, Mich. Although far from complete, the collection is of considerable interest, partly because among the 105 taxa represented, a surprisingly large number are "new" to the area, partly because some of these are species that on phytogeographical grounds could hardly be expected in the Mackenzie District, and, finally, because the collection provides information on the flora of an alpine valley not far from, and physiographically similar to, Brintnell Lake where the flora has been carefully studied and analysed.

The following information about the area from which his collection was obtained was kindly supplied by Mr. Arnold:

On June 25, 1960, Mr. Arnold and Mr. John P. Milton, also of the University of Michigan, were flown from Watson Lake, Y.T., to a small glacial lake, locally known as "Hole-in-the-Wall" Lake, in latitude $61^{\circ} 57' N.$ and longitude $127^{\circ} 13' W.$ The lake is one of four situated in a six-mile-long glaciated valley; the lakes, which are fed from small hanging glaciers and snowbanks, drain through a small stream into the South Nahanni River.

The elevation of the floor of the valley is approximately 4,000 feet above sea-level. On either side of the narrow valley, granitic mountains rise steeply 2,000 to 3,000 feet above the floor of the valley. In many places talus slopes of huge angular granite blocks encroach on the valley floor, their upper slopes resting against the rock walls of the mountainsides. The main axis of the valley is approximately East-West. On the north side three hot springs emerge 300 feet upslope. At the point of emergence the temperature of the springs was 115° F. Mr. Arnold's interest, being mainly ecological, centred around plant communities adjacent to the hot springs (Arnold, 1961).

Coniferous forest, composed of *Picea glauca* and *Abies lasiocarpa*, covers much of the valley floor and the lower talus slopes. On favourable sites some of the largest spruces attain a diameter of from 12 to 18 inches (DBH) and an approximate maximum height of 100 feet. Thickets of willow and alder border streams and wet meadows, while *Populus balsamifera* was found mainly in the vicinity of the hot springs. Scrubby timberline forest, composed mainly of alpine fir, extends to 5,000 feet elevation.

Mr. Arnold and his companion spent approximately two months exploring the valley and the adjacent mountains. The plants enumerated on the following pages were collected near their base camp by the lake, and on adjacent slopes at elevations between 3,550 and 6,500 feet.

The valley is approximately 15 miles south and 20 miles east of Brintnell Lake. Judging from Mr. Arnold's description and from photographs

PLATE I



Valley of the "Hole-in-the-Wall" Lake showing forested valley floor and steep mountainsides.

which he has most kindly supplied, the two areas are very similar physiographically. Brintnell Lake, however, is approximately 1,400 feet lower than "Hole-in-the-Wall" Lake and lacks hot springs. The Arnold collection, comprising 105 species, to which can be added *Alnus* (probably both *crispa* and *incana*), is far from complete and cannot be directly compared with that reported by Raup from Brintnell Lake. Nevertheless, a comparison, in so far as it can be made, brings out some rather peculiar discrepancies, among them that no less than 28 taxa, or more than one-fourth of the total number of species collected by Mr. Arnold, are lacking at Brintnell Lake. Among these 28 taxa some that in latitude $61^{\circ} 57' N.$ are approaching their northern limits or are localized at thermally favoured places such as hot springs are marked with an asterisk:

Athyrium Filix-femina ssp. *cyclosorum**, *Arctagrostis latifolia* ssp. *nakan-niensis*, n. ssp., *Phleum alpinum**, *Poa lanata*, *Carex paupercula**, *Luzula nivalis*, *Streptopus amplexifolius* var. *americanus**, *Veratrum Eschscholtzii*, *Habenaria dilatata**, *Listera cordata**, *Mitella nuda*, *Saxifraga adscendens* ssp. *coloradensis*, *Dryas alaskensis*, *Rubus pubescens*, *Sorbus scopulina*, *Geranium Richardsonii**, *Viola adunca* var. *minor*, *V. renifolia* var. *Brainerdii*, *Epilobium glandulosum* var. *perplexans*, *Kalmia polifolia*, *Rhododendron lapponicum*, *Mentha arvensis* var. *glabrata**, *Veronica americana**, *Valeriana sitchensis*, *Achillea nigrescens*, *Anaphalis margaritacea* var. *subalpina*, *Arnica amplexifolia* ssp. *prima*, and *Hieracium albiflorum*.*

PLATE II



Talus slopes encroaching on forested floor of valley.

Raup (1947) reported a total of 283 species and varieties in the flora of Brintnell Lake. Ably assisted in the field, he spent a little over two months collecting most intensively in a very small area where "every effort was made to collect the entire flora of the area." It is obvious, therefore, that, despite the close proximity of the two areas, their close physiographic similarity, and the absence of phytogeographic barriers, the composition of the two floras differs considerably. In view of the fact that Mr. Arnold has had very little previous field experience and was quite unfamiliar with the flora, the actual difference must be considerably larger than demonstrated by the following list.

Athyrium Filix-femina (L.) Roth ssp. **cyclosorum** (Rupr.) C. Chr.

Near hot spring, elev. 4,000 ft., No. 1A. Typical fronds with young sori on Aug. 1. A Pacific coast race in the Mackenzie District, known previously from a collection in the Liard valley.

Dryopteris fragrans (L.) Schott var. **remotiuscula** Kom.

Talus of dome, elev. 4,800 ft., 40-cm-tall fertile fronds, Nos. 1 and 2. The collection closes a gap between Lone Mt. near the mouth of N. Nahanni R. and Mt. Sheldon in central E. Yukon (Porsild, 1951).

Equisetum arvense L.

Lake shore gravel bank, elev. 3,800 ft., No. 87. Circumpolar, wide-ranging species.

Lycopodium alpinum L.

Hanging valley floor, elev. 4,800 ft., No. 98. Noted as common in Macmillan Pass (Porsild, 1945) and on Brintnell L. (Raup, 1947). Circumpolar, low-arctic, alpine.

L. annotinum L. var. **pungens** (La Pylaie) Desv.

In spruce woods, elev. 4,800 ft., No. 86. In the Mackenzie Mts. previously reported from Macmillan Pass (Porsild, 1945) and from Brintnell L. (Raup, 1947). Circumpolar, low-arctic, alpine.

Abies lasiocarpa (Hook.) Nutt.

Spruce-fir forest, elev. 4,000 ft., No. 42. Recorded from Macmillan Pass (Porsild, 1945) and from Brintnell L. (Raup, 1947). Cordilleran, mainly timberline species.

Juniperus communis L.

Talus slope, elev. 5,500 ft., No. 8. Probably common in the Mackenzie Mts. where it was previously recorded from Macmillan Pass (Porsild, 1945 and 1951) and from Brintnell L. (Raup, 1947). Circumpolar, low-arctic alpine.

Picea glauca (Moench) Voss

Spruce-fir forest, elev. 4,200 ft., No. 41. Wide-ranging boreal forest species.

Agrostis scabra Willd.

Near hot springs, elev. 4,000 ft., No. 48. Reported from MacMillan Pass, (Porsild, 1951) and from Brintnell L. (Raup, 1947) and is probably common in the Mackenzie Mts., especially on acid or neutral rock. Wide-ranging from Labrador to Alaska.

Arctagrostis arundinacea (Trin.) Beal

By hot spring, elev. 4,000 ft. Recorded from Macmillan Pass (Porsild, 1951) and from Brintnell L. (Raup, 1947). It is probably common in subalpine meadows throughout the Mackenzie Mts.

Arctagrostis latifolia (R. Br.) Griseb. ssp. ***nahanniensis*** n. ssp.

A. latifolia, Porsild, Nat. Mus. Canada, Bull. 101: 15, 1945. Raup, Sargentia 6: 122 (1947).

Perennis; culmi solitarii, laeves, erecti, 40–60 cm alti, crassi, folia caulinea 2–3 plana firma, acuminata, 8–20 cm longa et 4–9 mm lata, ligula hyalina, 4–5 mm oblonga, obtusa. Panicula sub anthesi 6–18 cm longa, ramis strictis scabriusculis, patentibus 4–6 cm longis. Spiculae 4–4.5 mm longae; glumae subaequilongae, circa 4 mm longae, acutae, purpureae, margine membranaceae. Antherae 2.7–3.0 mm longae, purpureae.

Perennial; culms 40–60 cm tall, smooth, bearing 2–3 flat, 8–20 cm long and 4–9 mm wide leaves with a very prominent 4–5 mm long hyaline, obtuse-tipped ligule. Panicle at the time of anthesis 6–18 cm long, the branches spreading, somewhat scabrous, naked in the lower third, the middle and lowermost 4–6 cm long. Spikelets 4–4.5 mm long, the glumes about 4 mm long, suffused with purple, hyaline-margined, acute. Anthers 2.7–3.0 long, purple.

Mackenzie Mts: Lake shore, in sand, elev. 3,800 ft., July 18, 1960, E. W. Arnold, No. 121 (Type, CAN.); Canol Rd. mountain range west of head of Bolstead Cr., July 26, 1944, V. C. Wynne-Edwards (Porsild, l.c.). Ssp. *nahanniensis* differs strikingly from the typical arctic plant in its taller growth and very much larger and spreading panicle, larger spikelets, and longer, thinner, hyaline-margined, and more acute glumes and lemmas, and in its somewhat longer anthers. It appears to be an endemic of the Mackenzie Mts.

Arctagrostis macrophylla Nash, judging from its description in Bull. N.Y. Bot. Gard. 2,6: 151, 1901 (thus far known only from the type collection near Dawson, Y.T., July 14, 1899, Williams) in habit resembles our plant from the Mackenzie Mountains. Hultén (1942), who has examined the type (NY), states that it “resembles var. *angustifolia* [*Arctagrostis angustifolia* Nash] fairly closely, except for the stamens, which are very long (about 2.3 mm).” However, a duplicate of the type of the latter in the National Herbarium of Canada differs markedly from our plant by its shorter glumes and spikelets (2.5 and 3.0 mm, respectively) and by its anthers, of which none is more than 1.2 mm long. Hultén, l.c., cites two collections of *Arctagrostis* from the Alaska Range (McKinley Park, Mexia, 2129 a, and Lignite, Anderson, 1189) which are said to “have very long anthers” and “...might represent a special race.” The Anderson collection, of which there is a duplicate in the National Herbarium of Canada, at any rate, does not resemble our plant and has spikelets that are only 3 mm long and anthers 2.0 mm long.

Phleum alpinum L.

By the edge of a stream, elev. 4,200 ft., No. 119. The species was noted in S.E. Yukon as common in alpine meadows, chiefly on Precambrian rocks east to Macmillan Pass, ascending to 5,600 ft. (Porsild, 1951) but has not been collected previously in the Mackenzie District or N.W.T.

Poa lanata Scribn. & Merr.

Lake shore, in sand, elev. 3,800 ft., No. 121A. The collection is the first from Mackenzie District and the N.W.T. Noted as not uncommon in S.E. Yukon on high mountains and on gravelly outwash plains of the eastern part of the Canol Road (Porsild, 1951).

Trisetum spicatum (L.) Richt. var. **Maidenii** (Gand.) Fern.

Lake shore, in sand, elev. 3,800 ft., No. 122. Noted by Raup (1947) on Brintnell Lake and by Porsild (1951) in Macmillan Pass. Probably common throughout the Mackenzie Mts.

Carex microchaeta Holm

C. nesophila Porsild, Sargentia 4: 21 (1943), Nat. Mus. Canada, Bull. 101: 16 (1945), and Raup, Sargentia 6: 136 (1947), not Holm.

Talus elev. 4,500 ft., No. 16.

C. micropetala is one of the most common sedges of high mountains of S.E. Yukon where it is often a dominant species on turf, not too dry slopes above timberline (Porsild, 1951). It has been collected in the Richardson Mts. west of the Mackenzie Delta and in the Mackenzie Mts. along the Canol Rd. (Porsild, 1943 and 1945), on Brintnell L. (Raup, 1947), and is probably common elsewhere, especially on Precambrian rocks. Its relation to *C. nesophila* Holm is discussed by Porsild (1951).

Carex paupercula Michx.

Near hot spring, elev. 4,000 ft., No. 45. This species was noted as rare in Yukon (Porsild) where it has been collected only a few times. In the Mackenzie District it is known only from the Athabasca, Gt. Slave Lake region (Raup, 1936), and from Gt. Bear Lake (Porsild, 1943). The present collection is the first from the Mackenzie Mts.

Eriophorum Scheuchzeri Hoppe

Margin of marsh, elev. 3,800 ft., No. 3. A wide-ranging arctic species, probably common in suitable places throughout the Mackenzie Mts.

Streptopus amplexifolius (L.) DC. var. **americanus** Schultes

In forest by the edge of hot spring, elev. 4,000 ft., No. 55. The collection is the second from the Mackenzie District where it was collected previously on the lower Liard R. (Jeffrey, 1961).

Veratrum Eschscholtzii A. Gray

In wet meadow, elev. 3,800 ft., Nos. 5 to 7. In the Mackenzie District previously collected in the Macmillan Pass (Porsild, 1945) and on the west slope of Liard Range (Jeffrey, 1961).

Habenaria dilatata (Pursh) Hook.

In meadow by a hot spring, elev. 4,000 ft., Nos. 36, 57, and 59. The fine series of specimens, flowering on July 10–28, constitutes the first record from the Mackenzie District. *H. dilatata* apparently is also a rare plant in Yukon where, thus far, it has been recorded only from Whitehorse and MacArthur Range (Porsild, 1951).

Listera cordata (L.) R. Br.

In forest by edge of hot spring, elev. 4,000 ft., No. 105. In the Mackenzie District previously collected but once, on the east slope of Liard Range (Jeffrey, 1961).

Populus balsamifera L.

By the edge of hot spring, elev. 4,000 ft., No. 100. Wide-ranging species of the boreal forest.

Salix arctica Pall.

Talus slope, elev. 4,800 ft., No. 117. Wide-ranging arctic-alpine species, probably common throughout the Mackenzie Mts.

Salix glauca L. var. *stenolepis* (Flod.) Polunin

S. glauca var. *perstipula* Raup. See Raup (1959).

Talus slope among alders, elev. 3,900 ft., No. 112. Wide-ranging arctic-alpine; in the Mackenzie Mts. first reported from Brintnell L. (Raup, 1947).

Salix planifolia Pursh

In forest by edge of hot spring, No. 101. Wide-ranging subarctic forest species.

Salix reticulata L.

By the edge of a stream, elev. 4,200 ft., No. 99. Wide-ranging arctic-alpine species.

Betula glandulosa Michx.

Talus, elev. 4,200 ft. and 4,800 ft., Nos. 22 and 29. Wide-ranging low-arctic species.

Oxyria digyna (L.) Hill

Wet meadow, elev. 4,800 ft., No. 77. Circumpolar, wide-ranging arctic-alpine.

Polygonum viviparum L.

On talus, elev. 4,500 ft., No. 124. Circumpolar, wide-ranging.

Cerastium Beeringianum Cham. & Schlecht.

Hot spring meadow, elev. 4,000 ft., No. 88A. Wide-ranging species of arctic E. Asia and N.W. America.

Silene acaulis L. var. *exscapa* (All.) DC.

Talus, elev. 6,200 ft., No. 11. Circumpolar, arctic-alpine.

***Stellaria laeta* Richards.**

Open meadow on valley floor, elev. 4,800 ft., No. 82. Wide-ranging N. Am. arctic.

***Aconitum delphinifolium* DC.**

In wet meadows, elev. 3,800 ft., Nos. 62, 73, and 111. A northwestern species apparently common in the Mackenzie and Richardson Mts. but not reaching east of the Mackenzie R.

***Anemone narcissiflora* L.**

Wet meadows, elev. 4,800 ft., No. 78. The specimens belong in the one-flowered continental race, ssp. *interior* Hult., which is common in alpine parts of Alaska and Yukon, reaching north to the Arctic slope and east to the Mackenzie Mts.

***Arabis lyrata* L. ssp. *kamchatica* (Fisch.) Hult.**

On sandy lake shore, elev. 3,800 ft., No. 123; hot spring meadow, elev. 4,000 ft., No. 88; talus slope, elev. 4,500 ft., No. 125. In the Mackenzie District previously recorded only from Gt. Bear Lake (Porsild, 1945) and from Brintnell Lake in the Mackenzie Mts. (Raup, 1947).

***Rhodiola integrifolia* Raf.**

Dry meadow on valley floor, elev. 3,800 ft., No. 91; dry meadow, elev. 4,200 ft., No. 120. A western alpine species common in Yukon and Alaska, reaching north to the Arctic Coast, eastward to the Mackenzie Delta, and to the Mackenzie Mts. where it has been collected a number of times.

***Mitella nuda* L.**

Spruce forest floor, elev. 3,800 ft., No. 110. Wide-ranging species of the boreal spruce forest, but in the northwest barely reaching the southern Mackenzie District and S.E. Yukon.

***Parnassia palustris* L. var. *neogaea* Fern.**

Wet meadow, elev. 4,800 ft., No. 37; meadow near hot spring, elev. 4,000 ft., No. 54. Wide-ranging from Labrador to Alaska.

***Ribes triste* Pall.**

In spruce woods, elev. 3,800 ft., flowering specimen on July 14, No. 97. Wide-ranging species of the boreal forest.

***Saxifraga nivalis* L.**

Base of talus, valley floor, elev. 4,700 ft., No. 20. Common in the eastern Canadian Arctic west to Gt. Bear Lake and in mountains of S.E. Yukon and probably in the southern Mackenzie Mts.; apparently lacking in central Alaska, but again common along the Pacific coast of Alaska and the shores of Bering Sea (Porsild, 1951).

***Saxifraga tricuspidata* Rottb.**

Talus slope, elev. 4,000 ft., No. 43. Wide-ranging, arctic alpine.

Dryas alaskensis Porsild

Talus slope, elev. 4,500 ft., No. 13. Endemic of alpine unglaciated parts of Alaska-Yukon, extending from Seward Peninsula to Richardson Mts. west of the Mackenzie Delta, south to St. Elias Range (Porsild, 1951). The present collection, which is the second from the Mackenzie District, is 350 miles beyond its most easterly known station in the Ogilvie Range of central Yukon.

Potentilla fruticosa L.

Talus slope, elev. 4,500 ft., No. 76. Wide-ranging boreal species.

Potentilla hyparctica Malte (*P. emarginata* Pursh, not Desf.)

Talus slope, elev. 4,600 ft., No. 114. Wide-ranging arctic-alpine species apparently rare on high mountains of S.E. Yukon, and in the Mackenzie District, thus far known only from a few earlier collections in the Mackenzie Mts. (Raup, 1947) and from the Arctic Coast.

Potentilla Ledebouriana Porsild (*P. uniflora* auctt.)

Talus slope, elev. 4,600 ft., No. 115. Cordilleran alpine species previously collected in the Mackenzie Mts. north to the Arctic Coast west of the Mackenzie Delta.

Rosa acicularis Lindl.

In spruce forest, elev. 3,800 ft., No. 103. Wide-ranging species of the boreal forest.

Rubus acaulis Michx.

Among alders, elev. 4,700 ft., No. 102. Wide-ranging boreal forest species.

Rubus Chamaemorus L.

Among alders by a stream, elev. 4,500 ft., No. 15. Circumpolar, low-arctic.

Rubus pubescens Raf.

Spruce woods on valley floor, elev. 4,800 ft., No. 84. An eastern boreal forest species reaching southern Mackenzie Dist. but not Yukon or Alaska. The present collection, which is the first from the Mackenzie Mts., extends the known western limit of the species by 200 miles.

Sorbus scopulina Greene

Woods near hot spring, elev. 4,000 ft., No. 51. The second collection from the Mackenzie District where the species has been reported from the lower Liard R. (Jeffrey, 1961).

Astragalus umbellatus Bge. (*A. frigidus* (L.) Gray var. *littoralis* (Hook.) Wats.)

Alpine meadow, elev. 4,800 ft., No. 19. Amphi-Beringian arctic-alpine species reaching the Mackenzie District along the Mackenzie-Yukon watershed where it has been collected in a number of places from the Arctic Coast south to Brintnell Lake (Porsild, 1945, 1951; Raup, 1947).

Geranium Richardsonii Fisch. & Trautv.

Meadows near hot spring, elev. 4,000 ft., flowering on July 14, No. 90. Cordilleran species with an apparently disjunct area in mountain of S.W. Yukon (Porsild, 1951), by the present collection extended to S.W. Mackenzie District.

Empetrum nigrum L.

Talus of Dome, elev. 4,500 ft., No. 21. The species is the arctic var. *hermaphroditum* (Lge.) Sør.

Wide-ranging, arctic-alpine.

Viola adunca Sm. var. **minor** (Hook.) Fern. (*V. labradorica* Schrank)

In meadow by hot spring, elev. 4,000 ft., No. 92. The western N. American range of this rather distinct, mainly eastern race is not very clear. In the Mackenzie District it has, thus far, been reported only from Gt. Bear Lake (Porsild, 1943).

Viola renifolia Gray var. **Brainerdii** (Greene) Fern.

In meadow by hot spring, elev. 4,000 ft., No. 93. Wide-ranging in the boreal forest, from the East barely reaching Yukon and Alaska.

Epilobium angustifolium L.

In gravel by lake shore, elev. 3,800 ft., Nos. 65, 66, 67, and 68. Wide-ranging boreal forest species.

Epilobium glandulosum Lehm. var. **perplexans** (Trel.) Fern.

In meadow by hot spring, elev. 4,000 ft., Nos. 96 and 104. The two collections as well as material collected by the writer at Liard Hotsprings (Porsild, 1961) closely match a series reported tentatively under this name, from S.E. Yukon (Porsild, 1951).

Epilobium lactiflorum Hausskn.

In meadow by hot spring, elev. 4,000 ft., No. 104A. A rare species in the Mackenzie District where otherwise it is known only in the Mackenzie Mts., from Macmillan Pass (Porsild, 1945) and Brintnell Lake (Raup, 1947).

Epilobium latifolium L.

Talus, elev. 4,800 ft., Nos. 23, 60, and 74. Circumpolar, arctic-alpine.

Heracleum lanatum Michx.

Edge of hot spring, elev. 4,000 ft., No. 33. Wide-ranging boreal forest species, in the Mackenzie Mts. collected previously in Macmillan Pass (Porsild, 1945) and at Brintnell L. (Raup, 1947).

Cornus canadensis L.

In meadows by hot springs, elev. 4,000 ft., No. 38. Wide-ranging boreal forest species.

Moneses uniflora (L.) Gray

In spruce woods, elev. 3,800 ft., No. 106. Wide-ranging boreal forest species.

Pyrola grandiflora Rad. var. *canadensis* (Andres) Porsild, in Rhod. 41: 273 (1939).

In spruce woods, elev. 3,800–4,800 ft., Nos. 70, 71, and 72. A northwestern American race of the circumpolar *P. grandiflora*. For the relation of var. *canadensis* to *P. grandiflora* and to var. *Gormanii* (Rydb.), see Porsild (l.c.).

Andromeda Polifolia L.

Talus, elev. 4,000–5,000 ft., Nos. 31 and 44. Wide-ranging species of subarctic-alpine tundra bogs.

Cassiope tetragona (L.) D. Don

Talus, elev. 4,800 ft., No. 30. It is of interest that the specimens belong in the circumpolar, arctic main race, of which the southern limit of continuous range is in S.E. Yukon, where it meets the Cordilleran, small-flowered, and short-peduncled race, ssp. *saximontana* (Small) Porsild, which reaches S.E. Yukon (Porsild, 1951) and the lower Liard R. (Raup, 1947).

Kalmia polifolia Wang. var. *microphylla* Hook.

Talus, elev. 4,800 ft., No. 28. The specimens belong in the not too well-marked, small-flowered, and small-leaved Cordilleran race, var. *microphylla* of alpine, mildly calcareous fens, where it is commonly associated with *Scirpus caespitosus* ssp. *austriacus*. The var. *microphylla* has been collected but once before in the Mackenzie District, in Macmillan Pass of the Mackenzie Mts. (Porsild, 1945).

Ledum groenlandicum Oed.

Talus, elev. 3,800 ft., No. 45; on sandy lake shore, elev. 3,800 ft., No. 50. Wide-ranging boreal forest species.

Phyllodoce glanduliflora (Hook.) Cov.

In meadow of open valley floor, elev. 4,800 ft., No. 18. This Cordilleran-Pacific coast species has been collected but once before in the Mackenzie Mts., at Brintnell Lake (Raup, 1947), 300 miles inland from its nearest station on the Pacific coast of Alaska and 500 miles disjunct from the northernmost outpost of the central Rocky Mt. population. The closely related, red-flowered *P. empetriformis* is common or even ubiquitous in S.E. Yukon in timberline *Abies lasiocarpa* forest (Porsild, 1951).

Rhododendron lapponicum (L.) Wahlenb.

Talus slope, elev. 5,200 ft., No. 24. Circumpolar-alpine tundra species.

Arctostaphylos rubra (Rehder & Wilson) Fern.

Talus slope, elev. 4,600 ft., No. 113. Wide-ranging subarctic-alpine.

Vaccinium uliginosum L. var. *typica*

Talus slope, elev. 4,800 ft., No. 85. Wide-ranging in open boreal forest.

Vaccinium Vitis-idaea L. var. *minus* Lodd.

On gravelly beach, elev. 3,800 ft., Nos. 46 and 63. Wide-ranging in open boreal forest.

***Gentiana glauca* Pall.**

In a wet meadow, elev. 4,200–4,800 ft., Nos. 40 and 64. An Amphi-Beringian species which in the Mackenzie Mts. barely reaches the Mackenzie District. In No. 64 the inflorescence is nodding, and, as is often the case when *G. glauca* grows on wet places, it produces slender leafy stolons terminating in a leafy rosette from the base of the stem. In No. 40 the inflorescence is erect, and the offsets are sessile or nearly so.

***Polemonium acutiflorum* Willd.**

In a wet meadow, elev. 4,800 ft., No. 25. Amphi-Beringian species reaching the Mackenzie District along the Continental Divide.

***Mertensia paniculata* (Ait.) G. Don**

In a meadow by hot spring, elev. 4,000 ft., No. 39. Wide-ranging species of the boreal forest reaching the southern part of the Mackenzie District.

***Mentha arvensis* L. var. *glabrata* (Benth.) S. R. Stewart**

In meadow by hot spring, elev. 4,000 ft., Nos. 56 and 95. Wide-ranging boreal forest species on the Mackenzie R. extending northward to Simpson.

***Pedicularis labradorica* Wirsing**

In alder thickets, elev. 4,500 ft., No. 27. Wide-ranging species of open boreal forest.

***Pedicularis sudetica* Willd.**

In alder thicket, elev. 4,500 ft., Nos. 17 and 26. Wide-ranging, arctic-alpine.

***Veronica alpina* L. var. *unalaschensis* Cham. & Schlecht.**

In a meadow by hot spring, elev. 4,000 ft., No. 35A. In the Mackenzie District previously reported from Brintnell Lake (Raup, 1947) and from Gt. Bear L. (Porsild, 1943).

***Veronica americana* Schwein.**

In a meadow by hot springs, elev. 4,000 ft., Nos. 35 and 94. Wide-ranging species of wet, springy places; near its northern limit mainly occurring in thermally favoured places. It has been reported from a few such places in S.E. Yukon (Porsild, 1951) but not previously from the Mackenzie District.

***Pinguicula villosa* L.**

In sphagnum bog, elev. 4,800 ft., No. 32. Widespread, but always localized in sphagnum bogs, from Labrador to Alaska northward to the limit of trees or slightly beyond.

***Linnaea borealis* L. var. *americana* (Forbes) Rehder**

In spruce wood, elev. 3,800 ft., Nos. 47 and 48. Wide-ranging through the boreal forest.

Viburnum edule (Michx.) Raf.

In wood near hot spring, elev. 4,000 ft., No. 53. Wide-ranging in rich spruce forest from Newfoundland to Alaska.

Campanula lasiocarpa Cham.

Talus slope, elev. 6,000 ft., No. 12; sandy lake shore, elev. 3,800 ft., No. 59. Amphi-Beringian alpine species previously collected a few times in the Mackenzie and Nahanni Mts. (Raup, 1947).

Achillea nigrescens (E. Mey.) Rydb. *A. borealis* Bong.

In wet meadows, elev. 4,200–4,800 ft., Nos. 126 and 109; in meadow by hot spring, elev. 4,000 ft., No. 107. Wide-ranging in tundra from Newfoundland and Alaska.

Anaphalis margaritacea (L.) Benth. & Hook. var. *subalpina* Gray

In meadow by hot spring, elev. 4,000 ft., No. 89. The specimens belong in the Cordilleran var. *subalpina*, which in its typical form seems well distinguished from the wide-ranging main species. The occurrence of *Anaphalis* in the Mackenzie Mts. is wholly unexpected. The station is the first for any *Anaphalis* from the Mackenzie District and is nearly 400 miles from the nearest population on the Pacific coast of Alaska and more than 500 miles beyond the northernmost station in the Canadian Rocky Mts.

Antennaria monocephala DC.

Talus slope, elev. 4,600 ft., No. 116. Amphi-Beringian alpine and tundra species reaching the Mackenzie District along the Yukon-Mackenzie Divide (Porsild, 1945; Raup, 1947).

Arnica amplexicaulis Nutt. ssp. *prima* Maguire

In meadow by hot spring, elev. 4,000 ft., No. 81. This well-marked race of *A. amplexicaulis* is otherwise known only from a small area along the central and western Pacific coast of Alaska; its occurrence in the Mackenzie Mts., more than 700 miles from its nearest Alaskan station on Kenai Pen., is most peculiar and unexpected. The fact that it was found on the Mackenzie Mts. by a hot spring and at an elevation of 4,000 ft. is suggestive of long isolation and of its survival somewhere above the upper limits of Pleistocene valley glaciation. In S.W. Yukon the writer (Porsild, 1951, p. 61) concluded that the exceptionally rich alpine flora, characterized by a remarkably high percentage of Cordilleran species, from above the 4,000-foot level must be much older than that of the valleys, and that the alpine flora survived the Pleistocene above the 4,000-foot level.

Artemisia arctica Less.

In a wet meadow, elev. 4,800 ft., No. 78A. Amphi-Beringian species probably common along the Yukon-Mackenzie Divide but not reaching east of the Mackenzie valley.

Artemisia Tilesii Ledeb. var. *elatior* T. & G.

In a meadow by hot spring, elev. 4,000 ft., No. 4; sandy lake shore, elev. 3,800 ft., No. 75. Wide-ranging Amphi-Beringian species of sandy and gravelly places.

Hieracium albiflorum Hook.

In meadow by hot spring, elev. 4,000 ft., No. 80. A Cordilleran species new to the Mackenzie District and disjunct by 300 miles from the nearest Pacific coast population and by 400 miles from its nearest Rocky Mt. station on the upper Peace R.

Senecio lugens Richards.

In meadow by hot spring, elev. 4,000 ft., No. 79A. Wide-ranging northwestern tundra species.

Senecio triangularis Hook.

In meadow by hot spring, elev. 4,000 ft., No. 79. Cordilleran species common in S.E. Yukon, and in the Mackenzie Mts. reaching north to Macmillan Pass (Porsild, 1945 and 1951).

Solidago multiradiata Ait.

Grassy slope, elev. 4,500 ft., No. 83. Wide-ranging alpine subarctic species.

Taraxacum alaskanum Rydb.

In a wet meadow, elev. 4,800 ft., No. 118. Northwestern alpine species previously collected in the Mackenzie and Richardson Mts. (Porsild, 1943; Raup, 1947).

* * *

A second and smaller collection of plants was made by Mr. Arnold between August 3 and 12 in the course of a two weeks' trip into the mountainous country adjacent to the base camp. There are no data on these specimens beyond that they "were collected in alpine meadows and on rock outcrops within a 20-mile radius of the base camp on "Hole-in-the-Wall" Lake. Although the specimens in the second collection are all small and scrappy, it has been possible to name them all. Those not represented in the main collection are listed below.

Luzula nivalis (Laest.) Beurl. No. 128.

Typical *L. nivalis* in N. America is an eastern arctic species reaching the Mackenzie District, Yukon, and Alaska mainly along the Arctic Coast. In the interior it is still common on the Precambrian rocks of the east end of Gt. Bear Lake, but west of the Mackenzie it is known only from a few disjunct alpine stations. In the Mackenzie Mts. it has been collected but once before, on the "Plains of Abraham," Mile 62 E. on the Canol Rd., elev. 6,000 ft. (Porsild, 1945). The present collection, although a mere scrap, by its branched inflorescence suggests the Amphi-Beringian var. *latifolia* (Kjellm.) Sam., in the Mackenzie District otherwise known only from the Mackenzie Delta and Richardson Mountains west of the Delta.

Parnassia fimbriata Koenig No. 130.

A Cordilleran species common in alpine situations in S.E. Yukon, reaching the Mackenzie Mts. in Macmillan Pass (Porsild, 1945) and on Brintnell Lake (Raup, 1947).

Saxifraga adscendens L. ssp. **oregonensis** (Raf.) Bacigalupi No. 131.

A Cordilleran race which apparently is very rare in the northern parts of its range where it is known only from a few widely disjunct alpine stations in Yukon and Alaska. The present collection is the first from the Mackenzie District and the Northwest Territories.

Hedysarum alpinum L. var. **americanum** Michx. No. 132.

Wide-ranging species of the boreal forest.

Myosotis alpestris Schm. ssp. **asiatica** Vestergr. No. 133.

Amphi-Beringian, reaching the Mackenzie Mts. where it has been collected a number of times (Porsild, 1945 and 1951; Raup, 1947).

Pedicularis capitata Adams. No. 134.

Circumpolar arctic-alpine (with large gaps in arctic Europe and E. Greenland). Apparently common on the Mackenzie Mts. (Porsild, 1945 and 1951; Raup, 1947).

Valeriana sitchensis Bong. No. 135.

A Pacific coast species common in rich, moist alpine meadows in S.E. Yukon but in the Mackenzie District thus far reported only from the Macmillan Pass (Porsild, 1945 and 1951).

Erigeron unalaschkensis (DC.) Vierh. No. 137.

Circumpolar, subarctic-alpine species, probably common in the Mackenzie Mts. where it has been reported from a number of places (Porsild, 1945, 1951; Raup, 1947).

Arnica Lessingii Greene No. 138.

Amphi-Beringian species reaching mountains of Yukon, northern British Columbia, and probably common in the Mackenzie and Richardson Mts. where it has been reported from a number of stations (Porsild, 1943, 1945, and 1951; Raup, 1947).

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THE VASCULAR FLORA OF LIARD HOTSPRINGS, B.C., WITH NOTES ON SOME BRYOPHYTES

BY A. E. PORSILD AND HOWARD A. CRUM

INTRODUCTION

Warm or hot springs, especially if situated in cold or temperate regions, generally attract the attention of travellers because the vegetation in the proximity of the springs is more luxuriant than that of the surroundings. Often, especially if the water is mineralized, the real or imagined therapeutic value of the springs adds to their interest. In temperate or warm climates warm springs attract attention mainly in arid regions, and the vegetation near them does not generally benefit from the heat of the springs.

In arctic or boreal regions, warm springs are of particular interest to the botanist and zoologist, because plants or invertebrate animals belonging in the floras or faunas of more temperate regions may have survived there as "relics" from earlier periods when the climate generally was warmer. Conversely, cold bogs or alpine situations far south of the Arctic often harbour plants that today have their main ranges in arctic or subarctic regions. Such situations may also be considered refugia, and the arctic plants that today are found there, disjunct from their main ranges, may be "relics" from colder periods. However, bogs and alpine situations are often quite extensive in area and may even be connected through continuous mountain ranges, such as in the Cordillera, to arctic or subarctic regions. For this reason, the possibility that these plants reached, and continue to reach, their present "disjunct" areas by ordinary means of migration cannot be ruled out. This could not likely have been the case with warm springs of arctic or subarctic regions, because they are commonly of very small area and are often geographically isolated so that the likelihood of plant diaspores of temperate species reaching them spontaneously is very small indeed and, in so far as invertebrate animals are concerned, non-existent.

In the North American Arctic and Subarctic, botanists have paid scant attention to the floras of warm springs. In Canada and Alaska the presence of a good many warm springs has been noted in the reports of geologists and topographers, and a few of them have been visited by botanists who have collected mainly the more spectacular or "unusual" plants growing there. As far as we know, no one has ever attempted to make warm springs the object of floristic or ecological studies.

In Greenland, perhaps mainly because the flora of that island has been studied longer, plants growing near warm springs have been noted more often, although even there, no systematic investigations of the floras or faunas of warm springs have been undertaken. The flora of Disko Island, on the middle west coast of Greenland, has been studied more thoroughly than that of any other part of Greenland, chiefly by

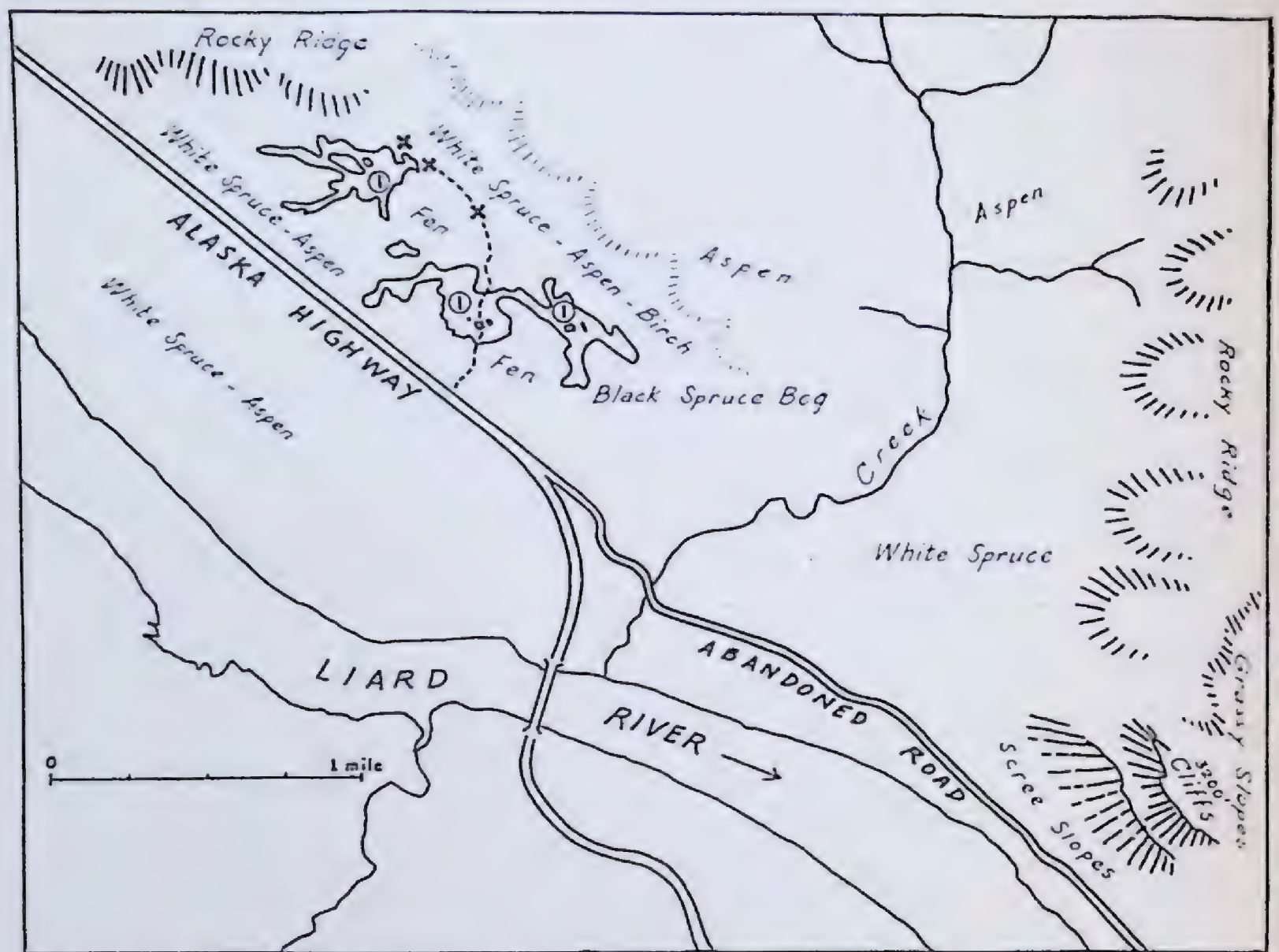


FIGURE 1. Sketch map of Liard Hotsprings and vicinity.

- 1. Shallow ponds below springs
- + Main Hotsprings
- trail from Alaska Highway to springs.

M. P. Porsild, who, in 1906, established a biological research station there. The flora of the island is noted for its large element of "southern" or non-arctic species that grow near the numerous, relatively warm springs where they attain a luxuriance seemingly out of place in an otherwise arctic environment. The presence near the springs of a rich and luxuriant vegetation on Disko was a matter of speculation even to the early Eskimo inhabitants, for, as related in an early Eskimo legend, the island was formerly situated far to the south whence it was moved by a powerful sorcerer who towed it behind his kayak to its present location. On the south coast, near the town of Godhavn, a natural bridge formed of basalt columns is to this day pointed out as "the place where the sorcerer fastened his seal skin towline."

The luxuriant vegetation near the Disko springs was already noted by Rink (1857 and 1877), and in more recent times brief accounts of the warm springs and their floras and invertebrate faunas are found in the writings of Porsild (1902, 1920, 1921), Seward (1922), Holttum (1922), and elsewhere. Porsild (1915) has listed about fifty "southern" species that are found on Disko, mainly in the vicinity of the warm springs. Some of those listed by him as "southern" are found also on the mainland where there are no warm springs and are perhaps better considered as thermophile continental species. The remainder, about 37 species, or no less than

16 per cent of the entire vascular flora of Disko, is, however, entirely restricted to the warm spring areas and must be considered a relict element from a period with a considerably warmer climate when the ranges of the southern elements in the flora of Greenland extended to or beyond the island of Disko. Most of the 37 species today find their northern limits well south of Disko Bay, and several are not found in Greenland except in the southernmost parts.

Liard Hotsprings, in approximate latitude $59^{\circ}10'$ N. and longitude 126° W., known as "Liard Tropical Valley" until the construction of the Alaska Highway, is situated near the Alaska Highway, on the north side of the broad U-shaped Liard Valley and approximately one mile west of where the suspension bridge crosses Liard River. The elevation above sea-level is about 1,300 feet. Although the springs have been well known locally for a long time, there are but few references to them in the literature. Camsell (1954), who devoted an entire chapter to the history of the hot springs, noted that they were well known to the officers of the Hudson's Bay Company and that the earliest reference to them probably is in the diary of Robert Campbell who, in 1837, was stationed at Fort Halkett. Camsell, himself, camped at the springs in 1898 and 1899. A brief description, with chemical analyses of the water from the two main springs, is given by Williams (1944), and a more detailed one by Rand (1944) who spent two weeks at Liard Crossing in August, 1943, making mammal and bird collections for the National Museum of Canada. On Plates XIII to XIX of his report, Rand shows a number of general views of the topography, the forests, and the so-called "beaver meadows and ponds" near the Hotsprings. The few botanists who have visited the Hotsprings (for complete list see p. 147-8) have noted the luxuriance of the vegetation and the remarkable concentration of temperate species, among them no less than fourteen species of orchids, but, except for a few citations of specimens collected there, have published no accounts of the flora or the vegetation.

No meteorological data are available for Liard Hotsprings. The nearest meteorological stations are at Watson Lake, Y.T., in latitude $60^{\circ}07'$ N. and longitude $128^{\circ}48'$ W., elevation 2,248 feet, and at Fort Nelson, B.C., in approximate latitude 59° N. and longitude 122° W. At both stations the climate is characteristically continental. A comparison of the climatic charts in *Climatological Atlas of Canada* (Thomas, 1953) shows that despite the slightly higher elevation of Watson Lake, the difference between the two stations in monthly mean temperatures and precipitation is slight. Liard Hotsprings, situated approximately half-way between Watson Lake and Fort Nelson, presumably has a very similar climate. In *Climatic Summaries* (Department of Transport, Meteorological Division, Toronto, 1948) the mean annual precipitation recorded for Watson Lake is 15 inches (381 mm) of which two-thirds falls as rain. The mean temperature recorded for July is 58° F. (14.4° C.), and for July and August the monthly average extreme high is 81° F. (27.2° C.) and the average number of days without frost is 90.

In so far as the vegetation is concerned, it may be safely assumed that the local climate in the proximity of the Hotsprings is even more favourable owing to higher ambient air temperatures, higher specific humidity, and



A. Liard River and suspension bridge; in background, low wooded mountain range to the south.



B. General view of Liard Valley looking west. To the left, Liard River; centre, Alaska Highway; and right, ponds below Hotsprings situated at foot of wooded slope.

a more abundant snow cover in winter because of rime deposit. The absence of frost in the ground in winter and the longer growing season must also favourably affect plant growth there.

On June 16 and again from June 24 to 30, the senior writer studied the vegetation in the vicinity of Liard Hotsprings. On his second visit he was most ably assisted in the collection and preparation of plants by his brother, Mr. Robert T. Porsild, of Johnsons Crossing, Y.T., who, from earlier field trips together, in Alaska and in the Mackenzie District, was known to him as an enthusiastic collector with a very good knowledge of the boreal flora.

At the time of our visit a number of late-flowering species, mainly in the *Gramineae* and the *Compositae* had not yet reached floration. It is to be expected, therefore, that species, especially in these groups, still in their prefloral state, may have been overlooked by us. The number is probably not large, because, owing to the effect of the springs, a great many species flower and fruit two to three weeks in advance of those in neighbouring and not thermally favoured habitats. Due, at least in part, to seasonal differences, phenological variations in the Hotsprings area of from two to three weeks are noted in the catalogue at the end of this paper for *Betula papyrifera* var. *commutata*, *Sorbus scopulina*, *Heracleum lanatum*, and for a number of other species.

The 445-odd numbers of vascular plants and bryophytes resulting from our collecting form the main basis of the following discussion and the annotated lists in which the senior author has dealt with the vascular plants, while Dr. Howard A. Crum has kindly undertaken to name and report on a small and no doubt very incomplete collection of bryophytes made by us in the immediate proximity of the Hotsprings. Dr. Dow V. Baxter of the University of Michigan, Ann Arbor, Mich., kindly determined *Polyporus betulinus* (Bull.) noted as common on large, dead or dying trunks of paper birch. Two amphipods collected in pools connected with the springs were determined by Dr. E. Bousfield of the National Museum of Canada.

THE HOT SPRINGS AND THEIR VEGETATION

The springs, of which there are several, emerge at the base of a gentle slope approximately one-quarter of a mile north of the Highway. At present the majority of them enter near the apex of a large, fan-shaped deposit of calcareous tufa, now covered by forest, except in the immediate vicinity of the active springs. In several places the overflow from the springs has cut through the tufa deposits, below which, and between the springs and the Highway, are extensive wet meadows or shallow basins where the water is held by tufa rims, giving the basins the appearance of rice-paddies. If, originally, these basins and meadows were the work of beavers, there is today no indication that beavers are active there. The beaver lodge mentioned by Rand, as well as some other low mounds situated near the edges of the meadows, is formed of tufa and probably is the remnant of partly collapsed former tufa terraces.

One-half mile west of Liard Crossing a small side road leads from the main highway to a clearing in the centre of an aspen wood. From the parking lot and campground a boardwalk leads across a shallow pond.

From the end of the boardwalk, a few hundred yards of a winding and very muddy path leads to the main hot spring. A rough log dam has been constructed across a shallow gully to form a small bathing pool. Two small springs emerge above this pool. In the largest, situated to the left, the water on June 25, 1960, measured 120° F. (49° C.); about one foot to the right a cool spring enters, in which water measured 62° F. (16.6° C.). In the pool itself the water near the bottom measured 98° F. (37° C.), while that near the surface was 110° F. (43.3° C.). A rough bath-house has been constructed beside the pool. A strong smell of sulphur was noticeable near this and all other hot springs in the area.

Almost directly above the pool a series of tufa terraces rise steeply. Between some of them are narrow pools of clear cool water 3 to 4 feet deep. The pools appear to be fed from a fair-sized brook which disappears underground near the apex of the tufa terrace. The temperature of the brook and of several of the pools tested was about 17° C. Above the terrace the course of the brook was followed for about half a mile up through a shallow ravine and a magnificent forest of tall, straight-boled aspens (*Populus tremuloides*).

The wet surface of the tufa cliffs and rims of the terrace is covered everywhere by a velvety-green moss polster composed mainly of lime-encrusted *Gymnostomum recurvirostrum* and *Cratoneuron falcatum*. The bottoms and the perpendicular walls of the pools likewise are lined with lime-encrusted *Fissidens grandifrons* and *Didymodon tophaceus*. In some pools near the apex of the terrace, masses of *Riccia fluitans* floated. The only animal life noted in the pools was some large amphipods (*Gammarus lacustris lacustris* Sars) and a tiny unidentified fish.

Although this tufa cone, by its striking arrangement of moss-green terraces and shiny, clear pools lined by bright flowers, is easily the most spectacular and attractive spot in the Hotsprings area, its vascular flora was disappointing and consisted only of species that are common or ubiquitous in the immediate vicinity of the springs. Most common, and always growing on the wet tufa rims of the pools, were *Mimulus guttatus*, *Erigeron philadelphicus*, *Lobelia Kalmii*, *Solidago lepida* var. *elongata*, *Pinguicula vulgaris*, and *Primula mistassinica*.

A few hundred yards beyond the bath-house is a natural pool about 100 yards long and about half as wide. It is situated on the edge of a flat tufa terrace approximately 50 feet above the meadow flat. The pool, which is approximately 12 feet deep in the middle, is fed by springs emerging in the soft, muddy bottom. Except for the local turbulence caused by bubbles of gas rising from the submerged springs, the pale blue waters in the pool are clear and limpid. The water temperature at the time of our visit was 104° F. (40° C.) and is said to vary very little throughout the year. In winter the appearance of the pool must be very striking, with rime densely covering the surrounding trees and bushes, and snow on the ground to the very edge of the steaming waters. Since my first visit, in 1944, the shape and dimensions of the pool have changed but little. Only the pristine appearance of its shorelines and of the surrounding forest has been marred by the inevitable litter left by the stream of visitors and bathers that daily visit the springs during the tourist season.

Below the large pool the tufa terrace extends as a low, water-parting ridge across the flat below. At present the overflow from the pool spills over the tufa rim in the southeastern corner. Near the base of the somewhat steeper west slope of the terrace, another spring emerges in which the water measured 43° C. The outflow from this spring, in a meandering brook, flows in a southwesterly direction through a very wet meadow. According to Mr. J. E. Parsons, who operates the bungalow camp at Liard Crossing and has lived in the area for a number of years, the overflow from all the hot springs disappears underground before reaching the highway, and apparently enters Liard River somewhere below water-level.

PLATE II



Moist tufa terraces above main Hotsprings, covered by dark-green polster, composed mainly of *Gymnostomum recurvirostrum* and *Cratoneuron falcatum*. On the narrow terraces grow *Erigeron philadelphicus*, *Primula mistassinica*, *Mimulus guttatus*, and *Solidago lepida* var. *elongata*.

Opposite the Hotsprings, on the south side of Liard Valley, forested mountain slopes rise to a treeless, flat-topped plateau from which rounded summits reach 2,000 to 3,000 feet above the floor of the valley. To the North the hills generally are lower and are densely forested for a considerable distance back of the river. One and a half miles east of the Hotsprings a

rocky ridge with a steep escarpment facing west cuts north at right angles to the river. The lower west and south slopes of this ridge are forested, but the cliff faces and screes are treeless. On June 26 we climbed this ridge to a rocky shoulder about three miles north and about 2,000 feet above the river which, here, is about 1,500 feet above sea-level. A number of arctic and alpine plants were found here on the cliffs and scree slopes, whereas on the east slope of the ridge we found rich, grassy slopes inhabited mainly by a foothill-grassland flora which included many species of Cordilleran affinity.

The flat river terrace between the river-bank and the highway is covered by a dense white spruce – aspen forest while north of the highway, on the better soils near the Hotsprings, aspen forest dominates.

In the immediate vicinity of the hot springs, on higher and well-drained ground underlain by tufa deposits, the trees are taller and the understory of shrubs and herbs is more luxuriant than elsewhere in the area. In view of the striking luxuriance of the vegetation and the warm, humid air in the vicinity of the springs, it is not surprising that the place has been called "Tropical Valley."

The white spruce here is *Picea glauca* var. *Porsildii*; some trees near the springs tower 100 feet high with stems measuring 18 inches D.B.H., and a few poplars (*Populus balsamifera*) growing near the springs have even thicker trunks, whereas some large specimens of the western paper birch (*Betula papyrifera* var. *commutata*) that here finds its northern limit also reach 18 inches in diameter. Near the large pool we noted a small clump of alpine fir (*Abies lasiocarpa*). The presence near the springs of this timber-line species at first made us wonder if, perhaps, we had come across a disjunct population of the eastern *Abies balsamea*. However, an abundance of old cones on the ground proved to be those of *A. lasiocarpa*. In rich, moist soil near the springs, western alder (*Alnus incana*) is tree-like and forest-forming, with stems measuring up to 8 inches in diameter and 30 to 40 feet in height.

The shrub layer in this rich mixed forest, which in luxuriance can well be compared to forest of similar composition near the Pacific Coast, is composed of *Cornus stolonifera*, *Viburnum edule*, *Rosa acicularis*, *Rubus strigosus*, *Salix Bebbiana*, *Prunus virginiana*, and *Ribes oxycanthoides*. In the herb layer we find *Dryopteris disjuncta*, *Botrychium virginianum*, *Equisetum arvense* and *E. pratense*, *Cinna latifolia*, *Sphenopholis intermedia*, *Maianthemum canadense* var. *interius*, *Streptopus amplexifolius* var. *americanus*, *Habenaria obtusata*, *H. hyperborea*, *Listera cordata*, *Thalictrum occidentale*, *Actaea rubra*, *Rubus pubescens*, *Geum macrophyllum* var. *perincisum*, *Aralia nudicaulis*, *Cornus canadensis*, *Pyrola asarifolia* var. *purpurea*, *Arctostaphylos rubra*, *Mertensia paniculata*, and *Galium triflorum*. In openings in the forest we found *Sorbus scopulina*, *Lonicera glaucescens*, *Ribes glandulosum* and *R. hudsonianum*, *Amelanchier alnifolia*, *Osmorhiza obtusa*, *Sanicle marilandica*, *Vicia americana*, *Lathyrus ochroleucus*, and *Aster ciliolatus*.

On lower but still well-drained ground, beyond the warming effect of the springs, some stands of pure white spruce were examined. In the feather-moss of the forest floor, the dominant species were *Ledum groenlandicum*, *Commandra livida*, *Linnaea borealis* var. *americana*, *Equisetum scirpoides*,

and *Mitella nuda*. Common also, but not dominant, were *Botrychium virginianum*, *Carex tenella* and *C. concinna*, *Rubus pubescens*, *Rosa acicularis*, *Potentilla fruticosa*, *Viola renifolia* var. *Brainerdii* and *V. rugulosa*, *Shepherdia canadensis*, *Epilobium angustifolium*, *Empetrum nigrum* var. *hermaphroditum*, *Pyrola virens* and *P. secunda*, *Moneses uniflora*, *Vaccinium Vitis-idaea*, *Petasites palmatus*, and *Lonicera glaucescens*.

On some flat or very gently sloping areas, still farther down the slope, the ground becomes progressively more boggy, and the white spruce is largely replaced by black spruce (*Picea mariana*). Probing through the organic surface layers even here revealed the presence of tufa deposits one to two feet below the surface that, together with seepage through the soil from higher lying ground, undoubtedly accounted for the predominance in these bogs of calcicolous fen species such as *Equisetum palustre*, *E. pratense* and *E. scirpoides*, *Botrychium virginianum*, *Carex Heleonastes*, *C. disperma*, *C. Preslii*, *C. gynocrates*, and *C. laeviculmis*, *Smilacina trifolia* (the last three in damp *Sphagnum* hollows), *Cypripedium Calceolus* and *C. passerinum*, *Habenaria orbiculata*, *Salix athabascensis* and *S. fallax*, *Betula glandulosa*, *Anemone parviflora*, *Drosera rotundifolia*, and *Oxycoccus microcarpus* (the last two on *Sphagnum* hummocks), *Potentilla fruticosa*, *Rubus acaulis*, and *Petasites palmatus*.

In open white spruce forest on the west slope of the tufa mound, growing in weathered calcareous tufa gravel, we noticed a few species not seen elsewhere in the Hotsprings area, among them the widely disjunct *Cynoglossum boreale*, besides *Aquilegia brevistyla*, *Apocynum androsaemifolium*, and *Arctostaphylos Uva-ursi* var. *adenotricha*, the last three wide-ranging species of the boreal forest. With these grew *Juniperus communis* var. *montana*, *Elymus innovatus*, *Oryzopsis asperifolia*, *Carex eburnea*, *Arabis Holboellii* var. *retrofracta*, *Dryas Drummondii*, *Linnaea borealis* var. *americana*, *Castilleja Raupii*, and *Galium boreale*, all but the first noted elsewhere in the area but not in the immediate vicinity of the springs.

Wet *Larix laricina* Fens and Wet Meadows

A rich and varied fen vegetation was found in the low, flat-lying ground that extends for about 1½ miles between the springs and the highway. It includes several flat terraces occupied by a succession of shallow pools held by low "strings," over which the water spills to the next pond below. All are fed by brooks from the hot springs. The temperature of the water varied with the distance from the springs, from 62° to 74° F. The "strings" are formed of organic matter heavily encrusted by calcium deposits, some of them already having the firmness of tufa while in others only the lower parts are mineralized. A soft white mud covers the bottom of the shallow pools; under this is a hard layer of tufa. A low, water-parting tufa ridge divides the meadow into an eastern and a western part. Along this ridge and in some other parts of the fen are low mounds on which grow stunted larches and black spruce. Among the trees are low thickets of *Salix candida* and *S. myrtillifolia*, *Ledum groenlandicum*, and *Potentilla fruticosa* with a rich herb layer in which the following species were common: *Selaginella selaginoides*, *Triglochin maritimum*, *Scirpus caespitosus* ssp. *austriacus*, *Eleocharis pauciflora*, *Carex viridula*, *Juncus alpinus* ssp. *nodulosus*, *J. balticus* var. *alaskanus*, *Tofieldia glutinosa*, *Orchis rotundifolia*, *Habenaria*

hyperborea, *Cypripedium Calceolus*, *Parnassia palustris* var. *neogaea*, *Viola nephrophylla*, *Primula mistassinica*, and *Pinguicula vulgaris*. In one spot in the meadows, in wet clay, we found a few tufts of the tiny *Scirpus Rollandii*, otherwise known from the Gulf of St. Lawrence and from the central Rocky Mountains.

Mainly growing on the "strings" by the edge of the pools were *Glyceria striata*, *Solidago lepida* var. *elongata*, *Erigeron philadelphicus*, *Aster junciformis*, *Lobelia Kalmii*, and *Drosera anglica*. Always sparingly, in the water of only some of the ponds were a few aquatics, all heavily encrusted with lime: *Potamogeton filiformis*, *Utricularia vulgaris* var. *americana*, *U. intermedia* and *U. ochroleuca*, the last far disjunct from its known range, and *Chara vulgaris*. On one *Utricularia* we collected a few specimens of the tiny amphipod *Hyalella asteca* Saussure.

PLATE III



Tufa rim below shallow pond fed by springs. Near the water grows *Erigeron philadelphicus* and *Aster junciformis*.

In very wet marshes below the western hot springs grew *Cicuta Douglasii*, *Typha latifolia*, *Lysimachia thyrsiflora*, and *Galium trifidum* among masses of *Scirpus validus*; the latter was also noted as abundant along the margins of some of the ponds.

The Hotsprings

In the immediate vicinity of the springs and along the overflow brooks near them, *Pteritis nodulosa* forms almost pure stands with fronds that by the end of June were 4 to 5 feet tall; in rich damp soil near the springs, and also in a rich meadow east of the main Hotsprings area were large patches of man-sized *Heracleum lanatum*. Also always associated with the springs are *Solidago lepida* var. *elongata*, barely coming into flower by the end of June, and *Athyrium Filix-femina* ssp. *cyclosorum*, *Cinna latifolia*, *Muhlenbergia racemosa* (the last growing always on wet tufa near the springs); *Phalaris arundinacea* and *Sphenopholis intermedia* in damp rich soil near the springs; *Eleocharis pauciflora* sometimes turf-forming on quaking calcareous mud near the orifice of springs; *Juncus nodosus* and *J. alpinus* ssp. *nodulosus*, both in wet mud; *Urtica Lyallii*, often associated with *Heracleum lanatum* and *Parietaria pennsylvanica*, the last seen only in one place when it formed a pure colony on wet mud above the orifice of a hot spring. *Ranunculus sceleratus* var. *multifidus* and *Cardamine pennsylvanica* were noted only a few times in wet mud in a brook; *Arabis glabrata* grew on wet tufa walls; *Viola nephrophylla* and *V. rugulosa* are both common in wet places near springs, *Circaea alpina* on rotten logs by a spring, *Cicuta Douglasii* with *Lysimachia thyrsiflora* in wet swamp near springs; *Mimulus guttatus* always near hot pools commonly associated with *Erigeron philadelphicus*, *Aster junciformis*, and *Solidago lepida*; *Lactuca* sp., too young for positive determination, was noted only in a few places by pools, and *Lobelia Kalmii* and *Primula mistassinica* commonly on wet tufa walls near the pools, and *Veronica americana* in wet mud by pools.

In all, 82 species of vascular plants were recorded as growing only in proximity to the hot springs or in meadows or fens affected by the springs. Forty-three of these are distinctly temperate species. For several of them Liard Hotsprings is the northernmost known limit, while the rest are species that in northern British Columbia, southern Mackenzie, Yukon, and Alaska are known only from hot springs or from otherwise thermally favoured stations: *Athyrium Filix-femina*, *Pteritis nodulosa*, *Botrychium virginianum*, *Muhlenbergia racemosa*, *Oryzopsis asperifolia*, *Phalaris arundinacea*, *Sphenopholis intermedia*, *Scirpus validus*, *S. Rollandii*, *Carex sitchensis*, *C. atherostachya* and *C. Prestii*, *Juncus nodosus*, *Streptopus amplexifolius* var. *americanus*, *Habenaria dilatata* and *H. orbiculata*, *Betula papyrifera* var. *commutata*, *Urtica Lyallii*, *Parietaria pennsylvanica*, *Chenopodium gigantospermum*, *Actaea rubra*, *Thalictrum occidentale*, *Arabis glabra*, *Prunus virginiana*, *Lathyrus ochroleucus*, *Viola nephrophylla* and *V. rugulosa*, *Circaea alpina*, *Cicuta Douglasii*, *Osmorhiza obtusa*, *Sanicula marilandica*, *Dodecatheon pauciflorum*, *Lysimachia thyrsiflora*, *Cynoglossum boreale*, *Mentha arvensis*, *Scutellaria epilobiifolia*, *Mimulus guttatus*, *Veronica americana*, *Lobelia Kalmii*, *Utricularia vulgaris* var. *americana*, *Solidago lepida* var. *elongata*, *Lactuca biennis*, and *Erigeron philadelphicus*.

The remaining 39 are temperate or at least thermophile species that, although many of them have been collected north of Liard Hotsprings, are always rare or local north of latitude 60° and always restricted to especially favoured and protected habitats:

Dryopteris disjuncta and *D. austriaca*, *Selaginella selaginoides*, *Typha latifolia*, *Cinna latifolia*, *Glyceria striata*, *Eleocharis pauciflora*, *Scirpus caespitosus* ssp. *austriacus*, *Carex Deweyana*, *C. Heleonastes*, *C. interior*, *C. laeviculmis* and *C. viridula*, *Juncus alpinus* ssp. *nodulosus*, *Tofieldia glutinosa*, *Smilacina stellata*, *Cypripedium Calceolus* and *C. passerinum*, *Listera cordata*, *Orchis rotundifolia*, *Habenaria hyperborea*, *Spiranthes Romanzoffiana*, *Alnus incana*, *Ranunculus sceleratus* var. *multifidus*, *Cardamine pennsylvanica*, *Drosera anglica*, *Parnassia parviflora*, *Geum macrophyllum* ssp. *perincisum*, *Rubus pubescens*, *Sorbus scopulina*, *Vicia americana*, *Epilobium glandulosum* var. *perplexans*, *Primula mistassinica*, *Utricularia intermedia* and *U. ochroleuca*, *Galium triflorum*, *Adoxa Moschatellina*, *Aster junciformis*, *A. modestus*, and *Hieracium canadense*.

Cliffs and Dry Grassy Slopes

On June 26 we climbed the rocky ridge to the east of Liard Hotsprings. At a point about 1½ miles east of the bridge, the ridge, which extends almost to the river, could here be reached by a road built during construction of the highway to a temporary bridge across the Liard, a few miles below the present one. The lower slopes of fairly consolidated rock scree are covered with an open aspen forest. Here we noted tufts of *Agropyron yukonense*, *Calamagrostis purpurascens*, and *Poa glauca*. *Maianthemum canadense* var. *interius* was common everywhere together with *Arenaria lateriflora*, *Anemone multifida* var. *hudsonica*, and *Pyrola virens*. Amongst the rocks in the open scree we collected *Ribes oxyacanthoides*, *Rosa Woodsii*, *Prunus pennsylvanica*, *Elaeagnus commutata*, *Potentilla arguta* ssp. *Convallaria*, *Lonicera glaucescens*, *Arenaria lateriflora*, *Arabis Holboellii* var. *retrofracta*, *Oxytropis spicata*, *Potentilla nivea* ssp. *Hookeriana*, *Stellaria longipes*, and *Artemisia borealis* ssp. *Purshii*. On cliffs of early Devonian sandstone and brown argillite (Williams, 1944) at the head of the scree, *Woodsia oregana* grew everywhere in rock crevices, sometimes associated with *W. ilvensis*, and in one or two places we saw clumps of *Dryopteris fragrans* var. *remotiuscula*. On a small rocky ledge grew *Draba oligosperma*, and not far from it *Salix glauca* var. *acutifolia* and a few tufts of *Draba lanceolata* and *Potentilla Ledebouriana*. From the south shoulder of the ridge, approximately 2,000 feet above the road and about 3,200 feet above sea-level, we obtained a fine view of the Liard River and valley and, to the right of it, of the wet meadows and pools below the springs. The springs and the hot pools were hidden from our view by the tall trees. On a small flat terrace, on the shoulder where we noted a Geodetic Survey marker, was an almost pure patch of *Dryas sylvatica*; by the edge of it grew clumps of *Arenaria rubella*, *Arnica alpina* ssp. *angustifolia*, and *Melandrium Ostenfeldii*. Right back of the shoulder was the lower edge of a scrubby forest of *Abies lasiocarpa*. In a moist ravine cutting across the ridge was a thicket of low aspen and *Salix Scouleriana*, where we noted *Maianthemum canadense* var. *interius*,

Corallorrhiza trifida, *Delphinium glaucum*, *Pyrola virens*, *Actaea rubra*, *Arnica cordifolia*, and in open places near the edge of the thicket *Vaccinium Vitis-idaea* and *Castilleja Raupii*.

On the east side of the ridge, grassy slopes extend almost from the base of the hill to the edge of the fir forest near the top of the ridge. In the closed turf of the slopes the following species were noted as dominants: *Agropyron yukonense*, *Calamagrostis purpurascens*, *Elymus innovatus*, *Poa glauca*, *Carex obtusata*, *Pulsatilla Ludoviciana*, *Saxifraga tricuspidata*, *Rosa Woodsii*, *Artemisia frigida*, and *Galium boreale*. Among the additional 50-odd species recorded from the slopes, the most noteworthy were *Juniperus communis* var. *montana* and *J. horizontalis*, *Carex supina* ssp. *spaniocarpa*, *C. Rossii*, *C. filifolia*, and *C. petasata*, dense "islands" of *Cerastium arvense*, a few plants of *Melandrium Ostenfeldii*, *Draba aurea*, *Chamaerhodos erecta* ssp. *Nuttallii*, the last only on gravelly outcrops, *Fragaria glauca*, *Potentilla furcata* and *P. pennsylvanica*, *Astragalus eucosmus*, *Lupinus arcticus*, *Oxytropis splendens*, *Viola adunca*, *Androsace septentrionalis*, *Penstemon Gormanii*, *Achillea nigrescens*, *Antennaria elegans*, *Aster alpinus* ssp. *Vierhapperi* and *A. sibiricus*, *Erigeron compositus* and *E. glabellus* ssp. *pubescens*, *Senecio cymbalarioides*, and *Solidago decumbens* var. *oreophila*. With the exception of three northwestern endemics, *Agropyron yukonense*, *Melandrium Ostenfeldii*, and *Penstemon Gormanii*, these are all wide-ranging grassland species, common along the eastern Rocky Mountain foothills through Alberta and British Columbia. Seventeen are of Cordilleran affinity; they are wide-ranging across Canada in the boreal forest, and six are wide-ranging arctic-alpine.

GEOGRAPHIC RELATIONS AND HISTORY OF THE HOTSPRINGS FLORA

Hultén (1937, and elsewhere) has stressed the phytogeographic importance of a land connection between Alaska and eastern Asia and an interchange of floras that has taken place across this land bridge in Pleistocene time. The fact that no trees or tree-like species are common to eastern Asia and northwestern North America strongly suggests that, when such a land bridge existed, the climate was too cold or too dry to permit tree growth and that the exchange must have been limited to tundra or grassland species. Hopkins (1959) has summed up the results of recent paleobotanical studies in western Alaska confirming "that the land bridge supported only treeless tundra during its most recent period of existence in late Wisconsin time. Moreover, a comparison of the vegetation of Alaska and Siberia suggests that the land bridge never supported forests during Pleistocene time." Hustich (1953, map fig. 7) shows the present course of the polar coniferous treeline indicating that a gap of 800 miles (1,300 km) exists between continuous forests in Siberia and North America.

Discussing the present-day continental limit of spruce forest in western Alaska, Hopkins (l.c.) notes that it "extends from the base of the Alaska Peninsula northward, parallel to the present coast but inland a few miles, to Kotzebue Sound and thence eastward, parallel to and a bit north of the Arctic Circle. During the Wisconsin glacial interval the western limit of spruce forest in Alaska lay even farther eastward. Pollen studies in the Cook Inlet (on the south coast of Alaska Peninsula) indicate, for example,

that the first vegetation to take root on glacial drift of Wisconsin age consisted of treeless tundra and that the first trees did not appear until several thousand years after the area was deglaciated and after the Bering land bridge was drowned by the rising sea." Griggs (1934 and 1934a) has shown that the spruce forest has been extending rapidly into the tundra areas on the Alaska Peninsula during recent decades and that the edge of the spruce forest in southwestern Alaska now lies farther westward than it has lain for many thousand years. There is, on the other hand, ample proof that spruce, larch, and perhaps other trees of the boreal forest grew, at least locally, in the Fairbanks region of central Alaska throughout Pleistocene time (Péwé, in litt.) although, during the postglacial optimum, the proportion of forest to grassland may have been different to that of the present (Péwé, 1957). However, if the many eastern forest species that are at present lacking had grown in postglacial time in central Alaska, it would seem likely that they, too, would have been able to survive somewhere in the mountains to the north or south, and, from such refugia, together with other members of the boreal forest, to reoccupy their lost territory on the interior Alaskan and Yukon plateaux.

Too little paleobotanical evidence for dating and charting the advances of the boreal forest is as yet available from the largely unglaciated central Alaska and Yukon plateaux. Some archaeological evidence (MacNeish, 1954, and oral communication) does, however, suggest that from five to seven thousand years ago large parts of the central Yukon plateau were predominantly grassland. If so, this would help to explain the present northern ranges of the Cordilleran alpine fir (*Abies lasiocarpa*) and lodgepole pine (*Pinus contorta* var. *latifolia*), as well as of a host of other Cordilleran species that have their present northern limit in the mountains of southeastern Yukon, and also the absence of larch (*Larix laricina*) and black spruce (*Picea mariana*) in large parts of southern and central Yukon. Also, if extensive grassland once existed in central Yukon and Alaska, the migration routes to western Alaska for white spruce (*Picea glauca*) and for many other boreal forest species would have been mainly along the Brooks Range of northern Alaska.

An examination of plant distribution maps showing the ranges of the 280-odd species and geographical races of vascular plants known to occur within a 2-mile radius of the hot springs at once shows that by far the largest numbers are wide-ranging, continental boreal forest species. No less than 115 of these are North American species while an additional 50 have an even wider range, being more or less circumpolar, occurring also in the boreal forest of Eurasia.

The second largest group is composed of wide-ranging Cordilleran species; 34 of them are continental, foothill species and in the Hotsprings area grow mainly on dry slopes and river-bank terraces. Seven are mesophytic species reaching the Pacific coast of Alaska and British Columbia.

A still smaller, but significant, number of eight species belong in a large group of mesophytic Pacific coast species, wide-ranging along the coastal mountains from the Alaska Peninsula southward through British Columbia to Washington, and beyond. Some species belonging in this group occupy, in addition, small disjunct areas in the interior of the Continent that may

or may not now be connected to their main areas by "corridors" through openings or passes through the Cordillera. In Canada one of the most important of these corridors appears to have been the Crowsnest Pass through which must have entered the large number of mesophytic Pacific Coast species now occurring as disjuncts on the east slope of the Continental Divide, in Waterton Lakes Park and adjacent parts to the north and south. Comparatively smaller numbers have reached other parts of the east slope of the Continental Divide where they are now found near the east end of Kicking Horse-Bow and Yellowhead passes. Still farther north, botanical exploration of recent years has brought to light a good many Pacific Coast species that must have entered the interior through the Liard River gap, penetrating as far as the southern extension of the Mackenzie Mountains, lower Liard Valley, upper Mackenzie Basin, and southeastern parts of Yukon Territory.

Comparatively few truly arctic or alpine species are found in the Liard Hotsprings area where none of the hills reach above timberline. Thus our list includes only 13 species of circumpolar, arctic-alpine range and eight that are wide-ranging in arctic-alpine parts of North America. Nearly all were growing on rocky outcrops or on open grassy slopes of the otherwise forested hills just east of the hot springs.

The ranges of another group of 18 species extend across Bering Strait into eastern Asia. Raup (1947) called them "Alaskan-Cordilleran species." Slightly more than half of them are what Hultén (1937) has called "Amphi-Beringian" species. The group is predominantly of arctic-alpine range and in North America extends through Alaska and Yukon eastward along the Arctic Coast, and through the mountains of the interior to the east slope of the Mackenzie Mountains, or beyond. Those found at the Liard Hotsprings are all lowland species, and several of them even reach eastward to near the west shores of Hudson Bay.

A residual group of some twenty species are North American endemics, mainly of limited and northwestern range. None reaches Asia. When their total ranges become better known, several of them may fall into the Cordilleran continental group.

In his analysis of the flora of the Brintnell Lake area in Mackenzie Mountains, N.W.T., Raup (1947) successfully employed a somewhat simplified adaptation of Hultén's (1937) now well-known method of plotting plant ranges into "equiformal progressive areas."

A plotting of the ranges of the Liard Hotspring plants, discussed above, would result in "equiformal" patterns that would differ from those obtained by Raup from the Mackenzie Mountains chiefly by the larger concentration of boreal forest species present in the lowland and more temperate flora of the Liard Valley.

In a paper discussing the geographical distribution of some key elements in the flora of Canada, the writer (Porsild, 1958, map 8) has shown that the boreal forest is composed of several elements (Figure 2) illustrated by the ranges of three common continental forest species: (1) wide-ranging from Newfoundland to western Alaska where some reach Bering Strait (*Picea mariana*), (2) wide-ranging from Newfoundland to southeastern Yukon and southern Mackenzie (*Mitella nuda*), and (3) with a similar

but somewhat more southern range (*Aster ciliolatus*). Neither group reaches the Pacific coast of Alaska or British Columbia. A fourth element, not shown in the map, is composed of temperate species of similar eastern ranges as group (3), from which they differ in having isolated or disjunct areas in central Yukon and Alaska where many of them are restricted to the vicinity of hot springs and thermally favoured habitats.

We have seen that the boreal forest element in the Liard Hotsprings flora is by far the largest, being composed of 115 North American species besides 50 of more or less circumpolar range. A closer examination of the ranges of these 165 species brings out some discontinuous patterns that must bear a close relation to the history and age of the boreal forest in northwestern North America.

To group (1) belong 50 species that, in common with the circumboreal species, are wide-ranging through interior Yukon and Alaska, having ranges more or less similar to that of *Picea mariana*. Among them are many shrubs and tall species that form an understory in the boreal forest. Being forest species, a good many of them do not quite reach the Bering Sea shore. Thirty-five that, like *Mitella nuda* (2), are ubiquitous in the Canadian

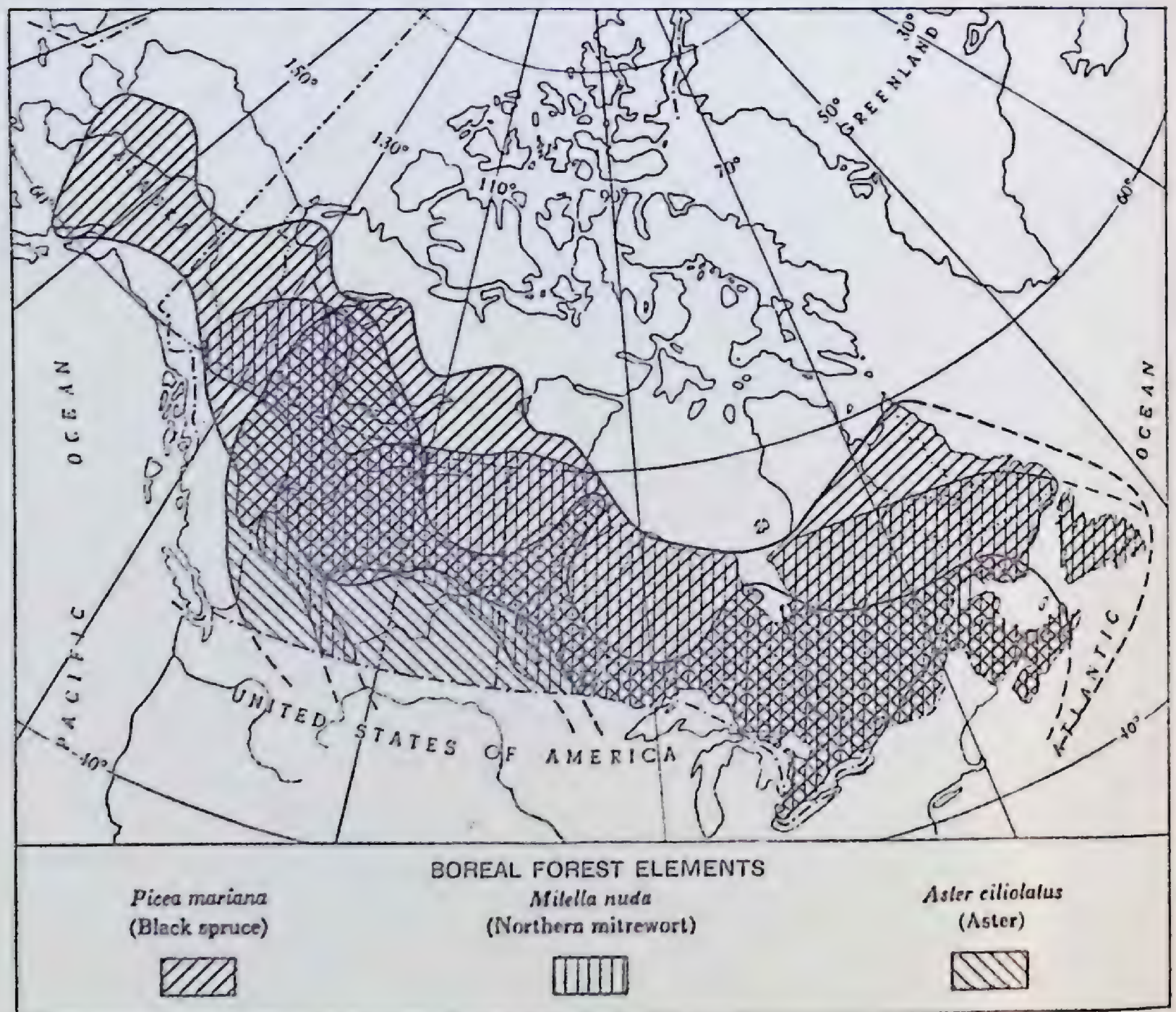


FIGURE 2. Boreal Forest Elements.

boreal forest, reach Yukon but not Alaska, and thirty (3) are wide-ranging across Canada through the southern parts of the boreal forest, reaching northern Alberta, northeastern British Columbia, southeastern Yukon, and the upper Mackenzie basin.

A fourth element, not shown in the map (Figure 2) is composed of temperate species of similar eastern ranges as group (3), from which they differ in having isolated or disjunct areas in central Yukon and Alaska where many of them are restricted to the vicinity of hot springs and thermally favoured habitats. In common with members of the preceding groups, these are continental species that do not reach the Pacific coast of British Columbia or Alaska. Some species representative of this fourth group are *Glyceria pulchella*, *G. striata* var. *stricta*, *Sphenopholis intermedia*, *Juncus nodulosus*, *Smilacina stellata*, *Orchis rotundifolia*, *Ribes glandulosum*, *Apocynum androsaemifolium*, and *Dracocephalum parviflorum*.

Among the fifty circumboreal forest species are many that, somewhere within their ranges, extend beyond the Polar treeline into the treeless tundra. No less than half of them are found in Greenland. The majority are herbaceous perennials, and the few that are woody are low or even prostrate. With few exceptions they could easily have migrated back and forth across a tundra-covered Bering Strait land bridge, and undoubtedly did so in Pleistocene time. Among the remaining 115 wide-ranging forest species in the Liard Hotsprings flora, 50 extend through interior Yukon and Alaska where they occupy the same range as does the circumboreal element. Although the present range of many of them reaches far into the treeless tundra, none crossed to eastern Asia. The fact that they are not found there strongly suggests that a land bridge was not available when they reached Bering Strait. It also suggests that they are eastern species, that they came to Alaska and Yukon from somewhere east of the Rocky Mountains, and that they are later arrivals than the circumboreal species, and this certainly must have been the case with the remaining 65 species (groups (2), (3), and (4)). Their climatic and biotic requirements are in most cases similar to those of group (1). The fact that many of them have not even reached Yukon, and still fewer Alaska, strongly suggests that they constitute a still more recent element in the northwestern flora.

ANNOTATED CATALOGUE OF VASCULAR PLANTS

In the following catalogue are listed the vascular plants known to the senior author, or recorded in literature, from within a two-mile radius of Liard Hotsprings. The few previous collections known to him are as follows:

1943: C. H. D. Clarke, Chief of the Fish and Wildlife Division of the Department of Lands and Forests, Toronto, when mammalogist of the National Parks Bureau of the Department of Mines and Resources, Ottawa, on June 24 made what is probably the first collection of vascular plants at Liard Hotsprings. The small collection is in the National Herbarium of Canada.

1943. Hugh M. Raup, Professor of Forestry and Director of Harvard Forest, Harvard University, and D. S. Correll of Texas Research Foundation, Renner, Texas, on July 29 and again on August 25, visited the Hotsprings. Their combined collection, which totals 85 numbers, is in the Gray Herbarium of Harvard University. Dr. Raup has kindly furnished a list of this still unpublished collection, allowing me to examine critical specimens and to cite some species not seen by us or by earlier collectors at the Hotsprings.

1944. A. E. Porsild, Chief Botanist of the National Herbarium of Canada, on June 2 spent an afternoon at the Hotsprings. The 71 numbers of vascular plants collected are in the National Herbarium of Canada. A few notable range extensions were reported by him (Porsild, 1951).

1946. J. P. Anderson, formerly florist at Juneau, Alaska, and Research Associate at Iowa State College, Ames, Iowa, from 1940 to the time of his death, visited the Hotsprings on June 21 and again on August 1. Anderson's herbarium is deposited at Iowa State College. A first set of his plants from the Hotsprings, now in the Herbarium of Riksmuseet, Stockholm, Sweden, was recorded by Hultén in "Flora of Alaska and Yukon," Part 10, from "Upper Yukon District" (Hultén, 1950), although Liard Hotsprings is actually on the Liard River, which is a tributary to the Mackenzie. A second and less complete set of the Anderson collection is in the National Herbarium of Canada.

1956. T. M. C. Taylor, Professor of Botany, University of British Columbia; A. Szczawinski, Curator of Botany, Provincial Museum, Victoria, B. C.; and M. Bell, visited the Hotsprings on June 15 and July 15. A few duplicates of their collections are in the National Herbarium of Canada, among them two numbers of *Chrysosplenium tetrandum*, the only record of that species from the Hotsprings.

In the catalogue the serial numbers cited without collectors' names, Nos. 9032 to 9108, are those of the author's 1944 collections. Nos. 21926 to 22300 indicate plants collected by him and his brother in June, 1960.

POLYPODIACEAE

Athyrium Filix-femina (L.) Roth. ssp. *cyclosorum* (Rupr.) C. Chr.

Noted as rare and very local in rich woods near Hotsprings, Nos. 21929-30 (young fronds with well-formed sori).

A Pacific coast plant that in the Canadian Rocky Mts. does not extend far east of the Continental Divide. In the northern parts of its range it appears to be equally scarce and local in the interior, having been collected only a few times in central Alaska and Yukon (Hult. 1941). It was collected recently in the Mackenzie District on the lower Liard.

Dryopteris austriaca (Jacq.) Woynar

Apparently uncommon and only a single plant, with well-formed fronds, was noted, No. 21931. Previously collected here by Clarke, No. 37, and Porsild, No. 9035.

D. austriaca s. str. appears to be a western race with a range somewhat similar to that of *Athyrium Filix-femina* ssp. *cyclosorum*. Thus far it has been collected only in a few places in Yukon Territory (Porsild, 1951).

Dryopteris disjuncta (Ledeb.) Morton. *D. Linnaeana* C. Chr.

Common in rich woods, No. 21932. Previously collected here, Porsild, No. 9033. Circumpolar forest species.

Dryopteris fragrans (L.) Schott

Rare, in rock crevices on south-facing mountain slopes east of Hotsprings, elev. 3,000 feet, No. 22192. The station is near the southern limit of the continuous range of the species in the West. In British Columbia otherwise known in the northern part of the province from Atlin and Mt. Selwyn (Taylor, 1956).

Pteritis nodulosa (Michx.) Nieuwl. *Onoclea Struthiopteris* Am. auctt.

Very common in the Hotsprings area where it forms dense colonies near and below the springs (Porsild, 1951), Nos. 9034 and 21933. The species was recently collected also on the lower Liard where it was not associated with hot springs. Wide-ranging forest species in the northern parts of its range mainly at hot springs or in exceptionally favoured habitats.

Woodsia ilvensis (L.) R. Br.

Rare, on cliffs of south-facing mountain slope east of Hotsprings, elev. 3,000 feet, No. 22193. The species which is perhaps always restricted to acid rocks is very rare in the province where it is known only from a few widely isolated stations (Okanagan, Cariboo Dist., and Stikine R., Taylor, 1956). Circumpolar, low-arctic.

Woodsia oregana D.C. Eat.

Common locally on dry rock screes and cliffs on south-facing mountain slope east of Hotsprings, elev. 2,500 ft., Nos. 22194-6. Cordilleran species, in the province previously known north to Ootsa L., lat. 53° N. (Taylor, 1956).

OPHIOGLOSSACEAE

Botrychium Lunaria (L.) Sw.

A single specimen, growing in damp soil in deep shade under tall *Heracleum lanatum* and *Urtica Lyallii*, No. 21934. Circumboreal.

Botrychium virginianum (L.) Sw.

Rather uncommon in open spruce woods, Nos. 21935-6. Previously reported from the area (Porsild, 1951); otherwise the northwestern limit of the species is Lone Mt. north of Simpson on the Mackenzie R. (Porsild, 1945). Wide-ranging boreal forest species.

EQUISETACEAE

Equisetum arvense L.

Ubiquitous and generally present in one form or another in most plant communities. In rich forest near the hot springs, and often in close

proximity to them, dense and pure colonies of plants, 3 to 4 feet tall, were noted on June 25, No. 21937. Previously collected here (Porsild, No. 9037). Circumpolar.

Equisetum hiemale L. var. *californicum* Milde. *E. prealtum* Raf.

Noted but once, on cliffs by a small pond just west of Liard Post, No. 22289. The nearest stations known are in S.E. Yukon (Porsild, 1951) and the upper Mackenzie (Raup, 1947).

Equisetum palustre L.

Rather uncommon and noted but a few times in wet places in black spruce bogs, No. 21938. Previously reported from the area, Anderson and Brown, No. 9853 (Hult. 1950). Circumboreal forest species.

Equisetum pratense Ehrh.

One small, local colony noted in a shaded place in rich spruce woods near brook from hot spring, No. 21939. Circumboreal forest species.

Equisetum scirpoides Michx.

Ubiquitous in dry spruce woods, Nos. 21940, 22268. Circumboreal.

Equisetum sylvaticum L. var. *pauciramosum* Milde

Noted as local in black spruce woods and only in acid and peaty soil, No. 21941. Wide-ranging in the boreal forest.

Equisetum variegatum Schleich.

Although apparently absent in the Hotsprings area proper, the species was noted by a cold seepage along the Liard R. near Liard Post. Circumpolar, arctic-alpine.

LYCOPODIACEAE

Lycopodium annotinum L.

Rare in dry spruce woods, No. 9038.

Although *L. alpinum*, *L. clavatum*, *L. complanatum*, *L. obscurum* var. *dendroideum*, and *L. Selago* are all known from northern British Columbia, S.W. Mackenzie, or S.E. Yukon, none of these were observed in the Hotsprings area. The reason for this is, no doubt, the absence of suitable habitats in this generally highly calcareous environment.

SELAGINELLACEAE

Selaginella selaginoides (L.) Link

Common in damp places in calcareous *Larix* bogs below springs, No. 21942. Previously collected here, Porsild, No. 9036. Circumpolar, boreal-alpine.

PINACEAE

Abies lasiocarpa (Hook.) Nutt.

A few well-grown trees were noted in a mixed aspen - white spruce forest near the main hot springs, No. 21943, where an abundance of old cones

and some seedlings were noted. Previously reported from here, Anderson & Brown, No. 1030 (Hult., 1950). On a mountain just east of the hot springs, alpine fir occurred abundantly in a moist ravine near 3,200 feet elev., No. 22197. The presence of this Cordilleran alpine species in the rich lowland forest in the hot springs is most peculiar.

***Juniperus communis* L. var. *montana* Ait.**

Common in open woods in vicinity of springs, No. 9039, and on south-facing slopes of mountain east of spring area, No. 21944. Wide-ranging, circumboreal alpine.

***Juniperus horizontalis* Moench**

Common on grassy, south-facing mountain slope east of springs, No. 22198. The species does not seem to have been recorded previously from the northernmost part of the province, the nearest station known to me being the upper Peace R. (Raup, 1934). Wide-ranging N. American species barely reaching S.E. Alaska.

***Larix laricina* (DuRoi) Koch var. *alaskensis* (Wight) Raup**

Common in wet, calcareous bogs below Hotsprings, No. 21945. Here, as elsewhere along the B.C. part of the Alaska Highway, the larch failed to flower this year. The same was the case in an isolated colony discovered later, in Jasper Park, Alta. Wide-ranging in the N. American boreal forest.

***Picea glauca* (Moench) Voss var. *Porsildii* Raup**

The dominant spruce on well-drained soil in the Hotsprings area and the only race of white spruce noted. Tall and rapidly growing trees near the spring measured 18 inches D.B.H. Cone production and regeneration appeared to be abundant, Nos. 9040 and 21946.

***Picea mariana* (Mill.) B.S.P.**

Several flat areas in the general vicinity of the present hot springs are occupied by black spruce bogs. Besides some of the ubiquitous "muskeg" species, the ground cover included a number of decidedly calciphilous species not otherwise belonging in black spruce bogs (See p. 139). Large black spruces here measured 9 to 10 inches D.B.H. with stems up to 50 to 60 feet, and reproduced abundantly, No. 21947. In Jasper Park, Alberta, black spruce growing in highly calcareous and largely mineral soil was briefly described (Porsild, 1959). In calcareous *Larix* bogs below the springs, stunted black spruce grows on calcareous tufa hummocks in which the temperature of the soil water toward the end of June measured 24° to 29° C., No. 21948.

***Pinus contorta* Loud. var. *latifolia* Engelm.**

No lodgepole pine was noted in immediate vicinity of the Hotsprings, but the tree is common on dry gravelly slopes east and west of Liard Crossing.

TYPHACEAE

Typha latifolia L.

A single small colony was noted in a wet swamp below the main Hotsprings, No. 21949. The station is the only one known from northern British Columbia, although in the Mackenzie Valley *Typha* ranges to lat. 65° N. Circumboreal, wide-ranging.

POTAMOGETONACEAE

Potamogeton filiformis Pers.

Fruiting but rather poorly developed specimens, perhaps because of a dense coating of algae, were noted together with *Utricularia vulgaris* and *Chara vulgaris* in the main outflow from the Hotsprings in water measuring 24° to 32° C., No. 21950, and in a small pond, fed by a cold spring in rich spruce woods. No other species of *Potamogeton* were noted in the Hotsprings area. First collected here in 1944, Porsild, No. 9044. Circumboreal, low-arctic.

SCHEUCHZERIAEAE

Triglochin maritimum L.

Common in calcareous *Larix* fens below the hot springs, and occasionally on tufa walls near the springs, Nos. 9041, 21951-2. Also Anderson & Brown, No. 9857 (Hult., 1950). Circumpolar, low-arctic.

Triglochin palustre L.

Less common than *T. maritimum* and, like it, growing on tufa walls near the springs. Circumpolar, low-arctic.

GRAMINEAE

Agropyron ? *trachycaulum* (Link) Malte

Immature *Agropyron*, probably of the above species, was noted as common by roadsides and near the parking lot.

Agropyron yukonense Scribn. & Merr.

Common in grassy places of south-facing mountain slope east of Hotsprings, No. 22199. The collection is a first record for British Columbia.

Agrostis scabra Willd.

A few plants were noted by the edge of springs growing in water measuring 43° C., No. 21953. Wide-ranging.

Bromus ciliatus L.

Young plants, evidently of this species, formed dense colonies in a clearing near main Hotsprings, No. 21954, where it had been collected previously, Anderson & Brown, No. 10362. Wide-ranging forest species.

Calamagrostis canadensis (Michx.) Beauv. var. *typica*

Noted as common in openings in forest and by the hot springs, No. 21955, and occasionally in boggy woods, No. 21956. Wide-ranging circumpolar forest species.

Calamagrostis inexpansa A. Gray

Occasional in wet places in black spruce and *Larix* bogs, No. 21957. Wide-ranging.

Calamagrostis lapponica (Wahlenb.) Hartm. var. **nearctica** Porsild

Wet meadow. Raup and Correll, No. 10909.

Calamagrostis purpurascens R. Br.

Very common on grassy slope of south-facing mountainside east of Hotsprings area, elev. 1,500 to 3,200 feet, No. 22201. N. American, arctic-alpine.

Cinna latifolia (Trev.) Griseb.

Occasional in rich mixed aspen and spruce woods near Hotsprings, No. 21958, where it had been collected previously (Anderson & Brown, No. 10365; Porsild, 1951). Wide-ranging circumboreal forest species.

Elymus canadensis L.

Occasional in rich mixed-woods and in openings in forest near springs, No. 21959. First collected in 1943 (Clarke, No. 42). Wide-ranging N. American grassland species.

Elymus innovatus Beal

Very common in open aspen forest on dry south-facing mountain slope east of Hotsprings, No. 22200, and on river terraces west of Liard Bridge, No. 22265. Cordilleran foothill species.

Glyceria striata (Lam.) Hitchc. var. **striata** (Scribn.) Fern.

Common in wet marshes below Hotsprings, often growing in water measuring 38° C., Nos. 21960-1, 22291; previously reported from here (Porsild, No. 9042, 1951.) Wide-ranging N. American boreal species here near its northern limit.

Hordeum jubatum L.

Noted as common by roadsides.

Muhlenbergia mexicana (L.) Trin.

Wet open places in woods, Raup and Correll, No. 10871.

Muhlenbergia racemosa (Michx.) B.S.P.

Uncommon, and noted only on the tufa walls near springs, No. 21962. Previously collected here by Anderson & Brown, No. 10364 (Hult. 1950) and by Raup and Correll, No. 10865. The station is disjunct and approximately 6 degrees of latitude north of previously known limit for this wide-ranging E. American lowland species.

Oryzopsis asperifolia Michx.

Occasional in open, dry woods, No. 21963. The station represents a considerable northwestward extension of the known range of this wide-ranging E. American forest species, the nearest stations known being near Ft. Smith on the Slave R. and the upper Peace R. (Raup, 1934).

***Phalaris arundinacea* L.**

Very common locally on moist slopes near Hotsprings where it forms dense colonies, Nos. 21964-6. Not seen elsewhere in the area. Previously reported from here (Porsild, 1951), No. 9043. Circumboreal, wide-ranging marsh species, here and elsewhere in the Northwest restricted to warm springs and similarly favoured habitats.

***Poa annua* L.**

Common along trail to Hotsprings where it was first noted in 1944.

***Poa glauca* M. Vahl**

Occasional in dry spruce forest, No. 21967, and on grassy slope of mountain east of Hotsprings, No. 22202. Circumpolar wide-ranging arctic-alpine.

***Poa pratensis* L.**

Common by roadsides near Hotsprings parking area where it is probably a recent introduction, No. 21968.

***Sphenopholis intermedia* (Rydb.) Rydb.**

Very rare and local, and noted only in one or two places by the edge of a hot pool, No. 21969. The station, which is the first for northern British Columbia, fills a gap between the only known Alaskan station: Tanana, Hotsprings, Alaska, Hitchcock, No. 4508 (Hitchc. 1939) and the upper Mackenzie drainage (Raup, 1936; Cody, 1956). A wide-ranging E. American forest species.

***Trisetum spicatum* (L.) Richt. var. *molle* (Michx.) Beal**

Open aspen woods along river-bank, No. 22270. Not seen near the springs but common elsewhere in the general area. Wide-ranging N. American boreal but non-arctic race.

CYPERACEAE

***Eleocharis pauciflora* (Lightf.) Link var. *Suksdorfiana* (Beauv.) Svens.**

Rather common in wet, calcareous mud in or near the springs and by brooks flowing from them. Our No. 21987 formed a turf on soft, quaking mud near the orifice of a spring; a thermometer placed in the mud between the rhizomes registered 43.3° C. The species was first collected here in 1943, Clarke, No. 55, and in 1944, Porsild, No. 9046 (1951). In the 1944 collection the achenes were fully formed on June 2, whereas in those of 1943 and 1960, collected three weeks later, the flowers were not yet expanded. A W. American race which in the northwest is restricted to hot springs and similarly favoured habitats.

Eriophorum angustifolium Honck. and *E. branchyantherum* Trautv. were noted along the Alaska Highway to the east and west but were not seen in Hotsprings area where suitable habitats are absent.

***Kobresia simpliciuscula* (Wahlenb.) Mack.**

Although some of the calcareous fens below the Hotsprings appeared suitable, we failed to detect this species there, the reason probably being that the temperature of the springs is too high for this arctic-alpine species. It does, however, occur at higher elevations and was collected in the pass between Muskwa and Racing R. near Mile 456 of the Alaska Highway (Porsild, No. 9004). This appears to be the first record for British Columbia.

Scirpus caespitosus L. ssp. **austriacus** (Pall.) Asch. & Graebn.

Common locally in *Larix* bogs below Hotsprings, No. 21988, where it was collected first in 1944 (Porsild, No. 9047). Wide-ranging low-arctic alpine.

Scirpus Rollandii Fern.

Very local in wet calcareous mud below Hotsprings, No. 21989. The station represents a first record for British Columbia and a considerable northward extension of the known range of this tiny species otherwise known from the Gulf of St. Lawrence, S.W. Saskatchewan, Banff and Jasper National Parks, Alta., and Colorado.

Scirpus validus Vahl

Common in wet marshes below Hotsprings, Nos. 21991-2, where it formed small colonies, with flowering heads on June 24. First collected here in 1944 (Porsild, No. 9045). Wide-ranging species but in the northwest of spotty and disrupted range and restricted to specially favoured habitats.

Carex aenea Fern.

In clearings along trail to Hotsprings, No. 23970, where it may be a recent introduction, although the station is well within the range of this Eastern prairie and grassland species.

Carex aquatilis Wahlenb.

By a small pond in spruce forest west of Liard Post, No. 22292, but not seen in the calcareous Hotsprings area, although collected there in 1944, (Porsild, No. 9055). Wide-ranging circumpolar boreal species.

Carex athrostachya Olney

In recent clearings east of Hotsprings area, No. 23971. In the northwest otherwise known from the Pacific Coast north to Kenai Pen., Alaska.

Carex capillaris L. var. **elongata** Olney

Common, in *Larix* fen below Hotsprings and in open, damp forest, No. 21972. Wide-ranging in N. American boreal forest.

Carex concinna R. Br.

Common everywhere in dry spruce forest, Nos. 21973 and 22271. First collected here in 1944, Porsild, No. 9054. Wide-ranging N. American boreal species.

Carex Deweyana Schw.

Common locally in rich aspen forest, No. 21974. Previously collected here by Anderson & Brown, No. 9869 (Porsild, 1951; Hult. 1950) N. American wide-ranging forest species.

Carex diandra Schrank

In meadow opening in spruce forest west of Liard Post, No. 22293, where it had been collected in 1944 (Porsild, No. 9052). Wide-ranging boreal bog species, in the Northwest barely reaching Alaska.

Carex disperma Dew.

Occasional in black spruce bogs, No. 21975. Wide-ranging circumboreal forest species, in N. America with a range similar to the preceding.

Carex eburnea Boott

Common in open aspen forest near river-bank, No. 22272, where it was collected by Anderson & Brown, No. 9854 (Hult., 1951). Wide-ranging boreal N. American forest species.

Carex filifolia Nutt.

Common on grassy slope of south-facing mountain east of Hotsprings, elev. 3,000 feet, No. 22203. The present station, which appears to be the first record for northern British Columbia, closes a gap between a northern population of S.E. Alaska, S. Yukon, and Central Mackenzie, and foothills and plains of southern Alberta, Saskatchewan, and Manitoba. Cordilleran foothill species.

Carex Garberi Fern.

Common in calcareous *Larix* bog below Hotsprings, No. 21976, where it was first collected in 1944, Porsild, No. 9048. Wide-ranging N. American boreal forest species.

Carex gynocrates Wormskj.

In moist calcareous hollow in black spruce bog, No. 21977. Earlier collected here, in 1944, Porsild, No. 9051. Circumpolar, low-arctic wide-ranging species.

Carex Heleonastes Ehrh.

Noted but once, in *Larix* fen below Hotsprings, No. 21978. The station is a first record for northern British Columbia and thus fills a very large gap between Kenai Peninsula and White Mts., Alaska, and S.W. Alberta. A species of peculiar and spotty distribution in N. America, known from about a dozen stations from central Yukon to southern and central Alaska. Additional exploration, no doubt, will add additional stations showing that the N. American range of *C. Heleonastes* is, perhaps, more continuous than suggested by the map giving its circumpolar range (Böcher, 1952, fig. 12).

Carex interior Bailey. *C. stellulata*, Hult. Fl. Al. & Yukon, p. 1723.

In calcareous *Larix* bog below Hotsprings, No. 21979. First collected here in 1944, Porsild, No. 9049, and by Anderson & Brown, No. 9857. N. American wide-ranging forest species.

Carex laeviculmis Meinsh.

Occasional in damp hollow of black spruce bog, No. 21980. This Amphipacific species in N. America is known otherwise from the Pacific coast of Alaska south to California and eastward to Alberta, Montana, and Idaho.

Carex leptalea Wahlenb.

Common in *Larix* bog below Hotsprings, where it often grew on quaking calcareous mud, Nos. 21981-2. First collected here by Anderson & Brown, No. 9857 (Hultén, 1950). Wide-ranging bog species of the N. American boreal forest zone.

Carex obtusata Liljebl.

Common on dry, grassy slope of south-facing mountain east of Hotsprings, No. 22204. Wide-ranging Amphi-Beringian foothill species.

Carex petasata Dew.

Dry grassy slopes of south-facing mountain east of Hotsprings, No. 22205. The collection represents a major northward extension of the known range of this species, in Canada otherwise known from foothills and prairies of southern Manitoba, Alberta, and British Columbia.

Carex praegracilis Boott

We did not rediscover this species collected in 1943 at Hotsprings, Clarke, No. 43, and reported by Porsild (1951). A Cordilleran prairie and foothill species, in Canada known from southern British Columbia east to Manitoba and from a few widely disjunct stations in Yukon and northern British Columbia.

Carex Preslii Steud.

Occasional on calcareous hummocks in black spruce bog, Nos. 21983-4. The range given by Mackenzie (N. Am.-Fl. 18: 133-4) is Alberta and Montana, and westward to British Columbia and California. The present collection thus constitutes a notable northward extension of its known range.

Carex praticola Rydb.

In the National Herbarium there is a specimen labelled "Liard Hotsprings" (Anderson & Brown, No. 9865). This species of dry grassy slopes was not likely taken in the Hotsprings area, but probably near the highway where it was noted as common on gravelly embankments. N. American wide-ranging grasslands species.

Carex Rossii Boott

Common on dry, grassy slopes of south-facing mountains east of Hotsprings, No. 22206. Cordilleran foothill species.

Carex rostrata Stokes

Common in a marsh by a forest pond west of Liard Post, Nos. 22294-5, but was not seen in Hotsprings area. Wide-ranging circumboreal species.

Carex sitchensis Presc.

Liard Hotsprings, 1943, Clarke, Nos. 49 and 50, Porsild (1951). Pacific Coast species reaching Alaska but not otherwise recorded from the interior.

Carex vaginata Tausch

Occasional in *Larix* bog below Hotsprings, No. 21985. Collected here also in 1944, Porsild, No. 9053, and Anderson & Brown, No. 9861 (Hult., 1950). Circumpolar, wide-ranging boreal species.

Carex viridula Michx.

Common, as above, No. 21986. First collected here, 1944. Porsild, No. 9050; Anderson & Brown, No. 9857 (Hult., 1950). Wide-ranging eastern N. American forest species, not reaching Alaska.

JUNCACEAE

Juncus alpinus Vill. ssp. **nodulosus** (Wahlenb.) Lindm.

Common in calcareous mud and in wet fens near and below springs, in one place growing in mud measuring 40° C., No. 21997. Wide-ranging boreal species.

Juncus balticus Willd. var. **alaskanus** (Hult.) Porsild

Very common in open places in calcareous *Larix* bogs below Hotsprings, Nos. 9056 and 22992-5. Reported from Hotsprings as *J. ater* Rydb. by Hult., 1950, p. 1728. (cf. Porsild, 1951) based on Anderson & Brown, No. 9916. Its range is from Alaska, Yukon eastward to Mackenzie Dist. and south to northern British Columbia. Probably also in E. Asia.

Juncus nodosus L. var. **genuinus**

Uncommon and local in calcareous mud in swampy flats below Hotsprings, No. 21996. First collected here by Anderson & Brown, No. 10367 (Hult., 1950). Wide-ranging in boreal N. America, barely reaching Alaska where it is known only from hot springs.

Luzula

The absence of such a common woodland species as *Luzula parviflora* (Ehrh.) Desv. in the Hotsprings area is peculiar but must be viewed in the light of the general absence or scarcity of all members of this genus in the upper Mackenzie drainage. *L. parviflora*, on the other hand, is common at least in the central and southern part of Yukon Territory (Porsild, 1951) and in central and southern Alaska as well as in the mountains of southern Alberta. The nearest stations for *L. spicata* are in the Mackenzie Mts. and the upper Peace R. (Raup, 1934 and 1947).

LILIACEAE

Maianthemum canadense Desv. var. **interius** Fern.

Common in rich woods near hot springs, No. 21998; occasional in open aspen woods on south-facing mountain slope east of Hotsprings where it ascends to 3,200 feet, Nos. 22207-8. The present station constitutes a slight westward extension of the known range of this plant which in northern British Columbia has been reported previously from the upper Peace R. (Raup, 1934), and from the S.W. corner of Mackenzie District (Raup, 1947). Eastern race of N. American forest species.

***Smilacina stellata* (L.) Desf.**

Common in rich woods of the Hotsprings area, No. 21999. First collected here in 1944, Porsild, No. 9059, and again by Anderson & Brown, No. 9868 (Hult. 1950). Eastern N. American forest species barely reaching Alaska.

***Smilacina trifolia* (L.) Desf.**

Common in rich woods near Hotsprings area, No. 22000, and in black spruce bog, No. 22001, near by. First collected here in 1944, Porsild, No. 9058, and again by Anderson & Brown, No. 9869 (Hult., 1950). The station represents a small westward extension of the known range of this eastern N. American forest bog species. Apparently a first record for British Columbia.

***Streptopus amplexifolius* (L.) DC. var. *americanus* Schultes**

Occasional in rich mixed woods near the hot springs, No. 22002. The present collection fills a gap between stations reported in S.E. Yukon (Porsild, 1951) and the upper Peace R. (Raup, 1934). A wide-ranging American race of the circumboreal *S. amplexifolius*.

***Tofieldia glutinosa* (Michx.) Pers.**

Very common in wet calcareous bogs below the hot springs, Nos. 22003-4. First reported from here by Porsild (1951), No. 9057. Wide-ranging Eastern N. American boreal species barely reaching central Alaska.

***Zygadenus elegans* Pursh**

Although well within the range of the species, we failed to discover it on the gravelly slopes east of Hotsprings area. In the National Herbarium is a specimen collected on the south bank near Liard Bridge (Rand, 33). Cordilleran foothill species.

ORCHIDACEAE

***Calypso bulbosa* (L.) Oakes**

Reported (verbal comm.) as common in dry spruce woods in the Hotsprings area and just west of Liard Post by Miss W. Steeves, who had spent a number of years in the area and who appeared to be well acquainted with the local flora. A search of likely habitats, however, failed to confirm the report. This, however, is not surprising in view of the notorious elusiveness of this species in which the aerial parts seem to vanish completely by the end of June.

Prompted by my statement (1951) that, although reported from Yukon in 1898 by J. B. Tyrrell, *Calypso* thus far had escaped later collectors, my brother, Mr. R. T. Porsild (in litt.), reported it as common in pine woods near Johnsons Crossing, Y.T., Mile 835 on the Alaska Highway. When I visited that place on August 14, 1953, a prolonged search at last revealed an abundance of corms, well hidden below the *Hylocomium* mat of the forest floor (Porsild, No. 18397). Later, flowering specimens, collected June 14, 1953, by R. T. Porsild, were received. In the National Herbarium there is a specimen collected on the Alaska Highway, 203

miles east of Nelson or just east of Liard Bridge (Rand, No. 48). Wide-ranging forest species, in N. America barely reaching central Alaska. Also in Europe and W. Asia.

Corallorrhiza trifida Chat.

Sparse in calcareous bog, No. 22005; in dense spruce woods, No. 22296; in wet leaf-mould, in aspen forest near timberline on mountain east of Hotsprings area, elev. 3,200 feet, No. 22209. First collected at Hotsprings in 1944, Porsild, No. 9063. Wide-ranging circumboreal species.

Cypripedium Calceolus L. var. **parviflorum** (Salisb.) Fern.

Rather local in calcareous *Larix* bog below Hotsprings, No. 22006, where it was first collected in 1944 (Porsild, No. 9061) and reported (*idem*, 1951). Other colonies were noted growing on hummocks in calcareous black spruce bog. Almost circumboreal, with large gaps in E. Asia and Alaska.

Cypripedium passerinum Richards.

Occasional in openings in rich woods but more common on hummocks in somewhat shaded places in calcareous *Larix* bogs below springs, No. 22007, where often associated with *Orchis rotundifolia*. The species was first collected here in 1943 by Clarke, No. 62. Wide-ranging N. American boreal forest species.

Goodyera repens (L.) R. Br. var. **ophioides** Fern.

Along the highway just east of Liard Crossing (Rand, No. 49). Wide-ranging in the N. American boreal forest species, from Newfoundland to eastern central Alaska. Also in Eurasia but with several large gaps between E. Asia and E. Alaska.

Habenaria dilatata (Pursh) Hook.

Collected at the hot springs in 1943 by Clarke, No. 60. Although diligently searched for, we did not rediscover the species. Wide-ranging N. American forest species.

Habenaria hyperborea (L.) R. Br.

The most common orchid in the area. Giant specimens 65 cm tall, in rich woods near hot springs, No. 22009; in calcareous *Larix* bog, No. 22010. Wide-ranging boreal forest species.

Habenaria obtusata (Pursh) Richards.

Noted as common in dense spruce woods in the Hotsprings area; ascending to 3,000 feet on mountains east of springs. Wide-ranging boreal forest species.

Habenaria orbiculata (Pursh) Torr.

Noted but twice, growing in dense *Hylocomium* mat in dense white spruce forest, Nos. 22011 and 22012. These collections extend the known

range of *H. orbiculata* to northernmost British Columbia. Wide-ranging forest species reaching southernmost Alaska and S. W. Mackenzie on the lower Liard and on Nahanni Mt.

Habenaria viridis (L.) R. Br. var. **bracteata** (Muhl. & Willd.) A. Gray

A single specimen collected by Clarke, No. 61, is tentatively referred here but is too young for positive determination. The station, however, is well within the known range of the species, and although we failed to discover new and better material, the species almost certainly occurs in the general area.

Listera borealis Morong

Although not collected in the Hotsprings area, the species was noted in old spruce forest along the Alaska Highway immediately east and west of the hot springs. Wide-ranging boreal forest species, from the East barely reaching central interior Alaska.

Listera cordata (L.) R. Br.

Rare, in shady woods near Hotsprings, No. 22013, where it was first collected in 1944 (Porsild, 1951).

Orchis rotundifolia Banks

Not uncommon on hummocks in calcareous *Larix* bogs below springs; giant, 12-flowered specimens up to 30 cm tall, No. 22014; in similar place in calcareous black spruce bog, No. 22015. First collected here in 1944 (Porsild, No. 9060). Wide-ranging eastern boreal forest species with disjunct stations in central interior but not western Alaska.

Spiranthes Romanzoffiana Cham. & Schlecht.

Noted only once in wet, calcareous depression along seepage through black spruce bog, No. 22016. Wide-ranging boreal forest species.

SALICACEAE

Populus balsamifera L.

A common species in the general area, where it often grows to large size on alluvial river flats. In the vicinity of the springs, trees appeared larger than those seen elsewhere; the trunks of some of the largest trees noted measured 24 inches D.B.H., Nos. 22017 and 22020. Wide-ranging boreal forest species.

Populus tremuloides Michx.

Likewise common in the general area. In the Hotsprings area, aspen forms almost pure stands on the slopes above the springs. A recent windfall measured 75 feet in length and 18 inches D.B.H. The lower 50 feet of the trunk was clear and perfectly straight, Nos. 22018 and 22019. Wide-ranging boreal forest species.

Salix arbusculoides Anders.

On south-facing mountain east of Hotsprings, 2-foot bushes on rocky ledge, elev. 3,000 feet, No. 22210, growing together with *S. Bebbiana* var. *depilis*. Common also on gravelly river-banks west of Liard Bridge, No. 22273. Northwestern boreal forest species, wide-ranging from Alaska to Hudson Bay.

Salix athabascensis Raup

Noted but once; erect bushes in open black spruce bog, No. 22021. The species was first collected here in 1943 (Clarke, No. 64) and later by Raup, No. 10907 (Raup, 1959). Northwestern boreal forest species ranging from central Alaska to Manitoba.

Salix Bebbiana Sarg.

Very common in openings in the forest. Bushes up to 20 feet tall. No. 22022. Low, erect bushes of typical var. *depilis* Raup were noted on a rocky ledge at 3,000 feet elev. on mountain east of Hotsprings, No. 22211 (cf. Raup, 1959). Wide-ranging species of the boreal forest.

Salix candida Flügge

Common in rich woods and in calcareous *Larix* bogs below springs, No. 22023. Earlier collections (Clarke, No. 65; Porsild, No. 9065; and Raup, No. 10908) were reported by Raup (1959). Wide-ranging eastern boreal forest species reaching central Mackenzie and S.E. Yukon.

Salix fallax Raup

Occasional in calcareous black spruce bog, No. 22024. An earlier collection (Clarke, 63) was reported from the Hotsprings by Raup (1959). Apparently endemic to the central Canadian Rocky Mountains but thus far known only for a few scattered stations between Jasper Park, Alta., and S.E. Yukon.

Salix glauca L. var. *acutifolia* (Anders.) Schn.

Erect dwarf bushes on a rocky ledge on mountain east of Hotsprings, No. 22212, where it was associated with *S. arbusculoides* and *S. Bebbiana* var. *depilis*. Collected at the hot springs in 1943 (Clarke, Nos. 8 and 13). Boreal forest species ranging from Alaska east to Hudson Bay.

Salix interior Rowley var. *pedicellata* (Anders.) Ball

Tall bushes growing on shelving river-bank inundated at time of high water, No. 22274. Wide-ranging species of the boreal forest.

Salix longistylis Rydb. *S. alaxensis* Cov. var. *longistylis* (Rydb.) Schn.

Tall bushes on shelving river-bank near upper limit of spring floods, No. 22275. Endemic to central Alaska, central Yukon, S.W. Mackenzie, and northern British Columbia. The more wide-ranging low arctic *S. alaxensis* extends from E. Asia eastward to northern Hudson Bay.

Salix myrtillofolia Anders.

Common on hummocks in wet calcareous bogs below Hotsprings, No. 22025. Wide-ranging species of the boreal forest which from the East reaches central but not western Alaska.

Salix padophylla Rydb. *S. pseudomonticola* Ball

Erect bushes 3 feet tall growing on hummocks in calcareous bog, No. 22026. Previously collected here in 1944 (Porsild, No. 9064). Boreal forest species, wide-ranging from James Bay to central Alaska.

Salix Scouleriana Barr¹

Erect bushes, 6 to 8 feet tall, in a ravine on mountain slope east of Hotsprings, elev. 3,200 feet, No. 22213. Cordilleran or W. American species reaching from Alaska east to Manitoba.

BETULACEAE

Alnus crispa (Ait.) Pursh

Foot of escarpment west of Hotsprings, No. 22027. Wide-ranging in the boreal forest.

Alnus incana (L.) Moench *A. tenuifolia* Nutt.

Common in mixed woods where it is often tree-like, up to 40 feet high, with trunks measuring 8 inches D.B.H., Nos. 22028 and 22297. Collected here in 1944 (Porsild, No. 9066). Western species ranging from Alaska to Manitoba.

Betula glandulosa Michx.

Common and occasionally forming small thickets in black spruce bogs and in open *Larix* fens, No. 22029. Wide-ranging, low-arctic.

Betula papyrifera Marsh var. **commutata** (Regel) Fern.

In the vicinity of Hotsprings some large trees measured 18 inches D.B.H., No. 22031. On June 28 the leaves and aments were fully developed. On June 2, 1944, twigs bearing young leaves and flowering aments were collected here, Porsild, No. 9071. As noted (Porsild, 1951), Liard Hotsprings appears to be the northernmost station known for this well-marked western race.

Betula papyrifera Marsh var. **neoalaskana** (Sarg.) Raup

Common in rich woods; although not so large as the var. *commutata*, one recent windfall measured 50 feet in height with 12 inches D.B.H. Judging from specimens collected here in 1944 by Porsild, Nos. 9067-9, with full-grown leaves and well-formed pistillate aments on June 2, the var. *neoalaskana* here is a week or ten days "earlier" than the var. *commutata*. Woodland species wide-ranging from central Alaska east to the Mackenzie valley and western Manitoba.

¹ Some additional species have been noted in the general area east and west of Hotsprings, and a number of others may be expected there. Those most likely to occur in lowland stations are *S. brachycarpa*, *S. glauca*, *S. lasiandra*, *S. MacCalliana*, *S. mackenziana*, *S. pedicellaris* var. *hypoglaucæ*, and *S. subcoerulea*, while the following may be expected in adjacent mountains: *S. arctica*, *S. Barclayi*, *S. niphoclada*, *S. planifolia*, *S. reticulata*, and *S. Richardsonii*.

URTICACEAE

Urtica gracilis Ait.

Forming dense thickets 6 feet tall on the enriched clearing in the forest where some years ago a trapper and prospector maintained a garden plot. Occasional also elsewhere in the Hotsprings area, No. 22032. Anderson & Brown, No. 7073 (Hult., 1950). Wide-ranging boreal forest species.

Urtica Lyallii Wats.

Collected in 1943 (Clarke, No. 69) and by the writer in 1944 (Porsild, 1951). The above collections represent an inland extension of this Pacific coast species.

Parietaria pennsylvanica Muhl.

Very local, by the hot springs where one almost pure colony of rank specimens 18 inches tall was noted growing in part-shade by the edge of hot pool measuring 45° C., No. 22033. The species was first collected here in 1943 (Clarke, No. 70) and later (Anderson & Brown, No. 9909; Hultén, 1950). The Liard Hotsprings station, 5 degrees of latitude north of Ft. McLeod, B.C., the nearest known station for this species, is sufficiently remote from travelled roads and trails to preclude the possibility of recent and accidental introduction. On June 28 our specimens had almost fully mature fruits.

The range of *Parietaria pennsylvanica* in Canada is peculiar and spotty. Macoun (1883) knew only seven collections, from Essex, in Northumberland County in southernmost Ontario; Cypress Hills, Sask.; Pembina R. Crossing, 50 mi. west of Edmonton, Alta.; and from Yale, Ft. St. James, Ft. McLeod, B.C.; the last in lat. 54° N. being then its northernmost station in Canada.

Since 1883 the known range of *Parietaria pennsylvanica* has not been extended greatly. Although not listed in Marie-Victorin's *Flore Laurentienne*, there are now in the Marie-Victorin Herbarium (MT) a number of Quebec collections mainly from Montreal Island and from places south of the city; some additional stations have been added from southernmost Ontario; in Manitoba, Scoggan (1957) has found it in several places in the southwest part of the province, and in the Marie-Victorin Herbarium there is a specimen from Otterburne, south of Winnipeg; despite Macoun's 1883 report, it is not included in Moss's *Flora of Alberta* (1959).

SANTALACEAE

Geocaulon lividum (Richards.) Fern.

Very common in dense spruce woods, No. 22034. Wide-ranging N. American forest species.

POLYGONACEAE

Rheum rhaponticum L.

Clarke, No. 67. A garden escape, not rediscovered by us.

CHENOPODIACEAE

Chenopodium gigantospermum Aellen

Common in the immediate vicinity of Hotsprings but noted nowhere else, Nos. 22035 and 22036. In N.W. America the species was previously known only from Dawson, Y.T., where the writer (1951) assumed it to be a recent introduction. The nearest station was then in the vicinity of Edmonton, Alta. The Liard Hotsprings station is approximately half-way in this 1,200-mile gap. Although the possibility of introduction cannot be precluded, its occurrence at the springs in no way was suggestive of this. Wide-ranging across Canada but, except for the two disjunct stations listed, not collected north of lat. 55°.

CARYOPHYLLACEAE

Arenaria lateriflora L.

Rather rare in open aspen woods and on grassy slopes on mountain east of Hotsprings, elev. about 1,500 feet, No. 22214. Wide-ranging circumboreal forest species.

Arenaria rubella (Wahlenb.) Sm.

A. verna L. var. *pubescens* (Cham. & Schlecht.) Fern.

Noted but once on stony ridge on mountains east of Hotsprings, elev. 2,500 feet, No. 22215. Circumpolar, arctic.

Cerastium arvense L. s. lat.

Forming small colonies, conspicuous by their pale grey-green colour against the deeper green of the dry, grassy slopes of mountain ridge east of Hotsprings, elev. 3,000 feet, No. 22216. Not noted elsewhere, although previously collected in Hotsprings area, Anderson & Brown, No. 9914 (Hult., 1950).

Cerastium arvense L. in Canada consists partly of an indigenous element and partly of a weedy and, no doubt, adventitious one. In the settled parts the two elements may hybridize. In the Canadian West no less than seven variations of *C. arvense* have been described by Greene: *C. angustatum*, Pitt., 4: 300 (1901); *C. campestre*, l.c. 300; *C. vestitum*, l.c. 301, all from Alberta; and *C. confertum*, l.c. 302; *C. subulatum*, Ott. Nat. 16: 36 (1902); *C. alsophilum*, l.c. 37, and *C. nitidum*, l.c. 37, from British Columbia. The types of these are all in the National Herbarium of Canada. From Newfoundland has been described *C. terrae-novae* Fern. & Wieg. Rhod. 22:176 (1920) which may likewise belong in the *C. arvense* complex.

Greene's seven western "species" are separated mainly on the absence or presence of glandular-hirtellous indument. *C. angustatum* and *C. campestre* appear to be wide-ranging prairie or foothill "species." The first is said to be up to 30 cm tall—"with ascending stems ending in long-peduncled rather contracted cymes." The indument of the entire plant is non-glandular. *C. campestre* is said to be lower, rather more leafy, usually with more or less decumbent-ascending short-peduncled cymes, the pedicels "with spreading hairs mostly gland-tipped and very viscid."

Hultén (1944) noted that *C. arvense* is variable in Alaska and that the inland plant occurring in Alaska-Yukon corresponds to *C. campestre* Greene; a comparison in the National Herbarium of Canada of the material from Alaska, Yukon, the Mackenzie District, and northern British Columbia shows that all have glandular-hirtellous pedicels and in general agree rather well with the type of *C. campestre*. The two collections from Liard Hotsprings are high-grown plants, in general habit rather similar to *C. angustatum*, but like the other northwestern material of *C. "arvense,"* both have glandular peduncles and pedicels.

Melandrium Ostenfeldii Porsild

Common locally at elev. 3,000 feet on grassy mountain slope east of Hotsprings, No. 22217. The present station extends the southward range of this species heretofore known from one station in the western Arctic Archipelago, from numerous collections from Gt. Bear Lake, and from isolated stations in the Mackenzie Delta and in mountains of southern Yukon Territory and northern Alaska. Our specimens had matured seeds on June 26.

Stellaria calycantha (Ledeb.) Bong.

Collected near the hot springs in 1946, Anderson & Brown, No. 9915 (CAN) but not seen by us. Wide-ranging boreal forest species.

Stellaria longipes Goldie s. str.

Locally common on sliderock slope elev. 2,000 feet, on south-facing mountain east of Hotsprings, No. 22218. Wide-ranging boreal species.

RANUNCULACEAE

Actaea rubra Ait.

Common in rich aspen woods near Hotsprings, with well-formed but still green fruits on June 24, No. 22037; in aspen-*Salix Scouleriana* thickets in a moist ravine on mountain east of Hotsprings, elev. 3,200 feet, No. 22219. First collected here in 1944, Porsild, No. 9075. Although the fruits are still immature, our specimens clearly are typical *A. rubra* and not the Pacific coast ssp. *arguta*. Wide-ranging N. American forest species.

Anemone multifida Poir. var. **hudsoniana** DC.

Noted but once, on dry rocky ridge west of Hotsprings, elev. 2,000 feet, No. 22039. Also collected here by Anderson & Brown, No. 9890 (Hult., 1950). Wide-ranging grassland species barely reaching central Alaska.

Anemone parviflora Michx.

Uncommon on calcareous hummocks in black spruce bog, No. 22040. Also collected here in 1944, Porsild, No. 9074. Wide-ranging N. American low-arctic-alpine species reaching E. Asia.

Anemone Richardsonii Hook.

Collected here in 1944, Porsild, No. 9073; the species must be rare and was not rediscovered by us in 1960. Wide-ranging N. American low-arctic-alpine species reaching E. Asia.

Aquilegia brevistyla Hook.

Noted but once in dry woods on calcareous tufa ridge, No. 22038. Also collected here by Anderson & Brown, No. 9887 (Hult. 1950). Western N. American forest species ranging from central Alaska to James B.

Delphinium glaucum Wats.

Noted but once, in aspen-*Salix Scouleriana* thickets in moist ravine on mountain east of Hotsprings, elev. 3,200 feet, No. 22220. A Cordilleran forest species ranging northward through Yukon and Alaska to the American shores of Bering Strait.

Pulsatilla Ludoviciana (Nutt.) Heller

Common on grassy slope of mountain east of Hotsprings, elev. 3,000 feet, No. 22221. Cordilleran foothills and plains species reaching central but not western Alaska.

Ranunculus sceleratus L. ssp. **multifidus** (Nutt.) Hult.

Noted only in hot mud or in the springs, Nos. 22041-4. Wide-ranging N. American forest species.

Thalictrum occidentale Gray. *T. Breitungii* Boivin

Common locally in rich woods near Hotsprings, No. 22045. A Cordilleran forest species reaching Yukon and central Alaska.

CRUCIFERAE

Arabis glabra (L.) Bernh.

Noted only in the immediate vicinity of hot springs and pools, No. 22046, where it was previously collected by Clarke, No. 71, Porsild, No. 9076, and Anderson & Brown, No. 9897. The last number, on June 21, had almost mature fruits whereas our specimens on June 25 had flowers and young fruits no further developed than in my 1944 collections on June 2. The species undoubtedly is indigenous at the Hotsprings. In the National Herbarium of Canada there is a specimen collected at Johnsons Crossing, Y. T. A Cordilleran species reaching southernmost Yukon.

Arabis Holboellii Hornem. var. **retrofracta** (Grah.) Rydb.

In dry woods on tufa cliffs near Hotsprings, No. 22047; fruiting specimens on sliderock on mountain slope east of Hotsprings, elev. 2,000 feet, No. 22222.

West American foothill race ranging north to central Alaska and eastward to the Mackenzie drainage and to Lake Superior.

Cardamine pennsylvanica Muhl.

Rare to occasional growing in soft mud by the edge of hot springs or by the hot pools below, Nos. 22048-9; the last number had almost mature siliques on June 24. Collected previously by Clarke, No. 72, Porsild, No. 9077, and Anderson & Brown, No. 9895. Wide-ranging E. American forest species, in the west reaching Yukon. The leaflets in the last two

numbers are almost orbicular as in *C. oligosperma* Nutt. of the Pacific Coast. The specimens, however, are two young and immature for positive determination.

***Draba aurea* M. Vahl**

Occasional on grassy slope of mountain east of Hotsprings; flowering and fruiting specimens on June 26 by *Citellus* burrows, No. 22223. Wide-ranging N. American low-arctic, montane species.

***Draba lanceolata* Royle**

Fruiting specimens on dry, rocky ledges on mountain east of Hotsprings, elev. 3,000 feet, No. 22224. Wide-ranging boreal N. American - E. Asiatic species.

***Draba oligosperma* Hook.**

A few fruiting specimens on sliderock slope, on mountain east of Hotsprings, elev. 3,000 feet, No. 22225. Cordilleran alpine species reaching Mackenzie, Yukon, and central Alaska.

DROSERACEAE

***Drosera anglica* Huds.**

Rare in wet moss at the base of hummocks in calcareous fen below Hotsprings, flowering on June 25, No. 22050. Collected here in 1944, Porsild No. 9078 (reported as *D. intermedia*, Porsild, 1951) and Anderson & Brown, No. 9905 (Hult., 1950). Wide-ranging circumboreal (with large gaps) species, in N. America from Newfoundland to Alaska north to central Yukon and Gt. Bear Lake (Porsild, l.c.).

***Drosera rotundifolia* L.**

Noted in a number of places near the hot springs and in calcareous fens, commonly growing on wet tufa rims near hot pools, No. 22051, where it was first collected in 1944, Porsild, No. 9079. Circumboreal lowland species, in Canada with slightly more northern range than *D. anglica*.

SAXIFRAGACEAE

***Chrysosplenium tetrandrum* (Lund) Fr.**

In wet soil in mixed woods, 1956, Taylor, Szczawinski & Bell, Nos. 317 and 1469, CAN. Circumpolar, arctic-alpine.

***Mitella nuda* L.**

Common everywhere in the Hotsprings area in dry spruce woods, Nos. 22052-3, where it was collected in 1944, Porsild, No. 9080. The absence of *Mitella nuda* in western parts of Yukon and all Alaska (except, perhaps, the panhandle), as well as in Siberia east of long. 138° E., is peculiar. In N. America it is a characteristic component in the ground flora of boreal dry spruce forest from Newfoundland-Ungava west to interior British Columbia, southern Yukon, and Mackenzie. In Asia it occupies a large area between Ajan and Yenisei south into Manchuria (Hultén, 1937). The reasons for its

absence in forested parts of interior N.W. America must be historical or, perhaps some biological barrier somehow prevented it and a number of other wide-ranging ground species of the boreal forest from following in the wake of the apparently rapid post-Pleistocene advance of the boreal spruce forest into interior Yukon and Alaska. (See also p. 145-7).

Parnassia montanensis Fern. & Rydb.

A Cordilleran species reaching southern Yukon (Porsild, 1951) and central Mackenzie (Porsild, 1945). It was collected in the Hotsprings area in 1943, Clarke, No. 75.

Parnassia palustris L. ssp. **neogaea** (Fern.) Hult.

P. obtusiflora Rupr. acc. to Löve (1950).

Common in calcareous mud in wet *Larix* bogs below Hotsprings, No. 22054, and on tufa walls by springs, often growing near water measuring 38° C. or over, No. 22055. Wide-ranging (circumpolar, acc. Löve, 1950) boreal-alpine.

Parnassia parviflora DC.

Wide-ranging N. American boreal forest species, ranging from Newfoundland to British Columbia north to southern Yukon. A single specimen was collected near the hot springs in 1943 (Clarke, No. 74) where we failed to rediscover it.

Ribes glandulosum Grauer

Occasional in rich spruce forest, No. 22056. Specimens with well-formed green fruits on June 2, collected here in 1944 (Porsild, No. 9082). An eastern species of the boreal forest ranging across Canada from Newfoundland-Labrador to S.E. Yukon north to the limit of trees. Apparently rare and disjunct in Alaska where thus far it has been collected but a few times, and mainly at Hotsprings (Porsild, 1951). (See also Hultén, 1945.)

Ribes hudsonianum Richards.

Rather uncommon in rich woods in the Hotsprings area, Nos. 22057-8, where it was collected previously by Anderson & Brown, No. 3001 (Hult., 1950). A Northwest American boreal calciphilous forest species, wide-ranging from Alaska to Hudson Bay. Isolated on the east shore of Hudson Bay and at Lake Mistassini, Que., on dolomitic rocks.

Ribes oxyacanthoides L.

Common on sliderock slope on mountain east of Hotsprings, No. 22226. Specimens with almost mature fruits on June 25, in rich woods near Hotsprings, No. 22068. Collected here in 1944 (Porsild, No. 9081) and by Anderson & Brown, No. 3002 (Hultén, 1950). Calciphilous forest species ranging from Yukon to Hudson Bay.

Saxifraga aizoides L.

Calciphilous Amphi-Atlantic, arctic-alpine species. Although not actually seen in the Hotsprings area, it is common at somewhat higher elevations along the Alaska Highway south and west of Liard Crossing.

Saxifraga tricuspidata Rottb.

Very common on dry, grassy upper slope of mountain east of Hotsprings. Wide-ranging N. American arctic-alpine.

ROSACEAE

Amelanchier alnifolia (Nutt.) Nutt.

Rather common in openings in forest, No. 22059; with well-formed but still green fruits, June 25, on scree slope of mountain east of Hotsprings, No. 22227. Cordilleran foothill species, the northern range of which extends to central Alaska and central Mackenzie.

Chamaerhodos erecta (L.) Bunge ssp. **Nuttallii** (T. & G.) Hult.

Common in stony and gravelly openings on grassy slope of mountain east of Hotsprings, elev. 2,500 feet, No. 22228.

Cordilleran foothill species reaching southern central Yukon, Lake Athabasca and east to Manitoba south through the mountains of Alberta and British Columbia to Colorado.

Dryas Drummondii Richards.

A common and ubiquitous species of calcareous gravelly floodplains and river-banks in the general area. Near the Hotsprings found only in one local area in open places on tufa cliffs, No. 22060.

Cordilleran species ranging from Montana-Oregon north through Alberta and British Columbia, Mackenzie and Yukon to southern and central Alaska but not reaching western Alaska or the east shore of Bering Strait. Disjunct isolated stations on Lake Superior, the Gulf of St. Lawrence, and western Newfoundland.

Dryas sylvatica (Hult.) Porsild

Forming large colonies on pebbly river terrace, on south bank of Liard R., No. 22276; forming dense mats on stony ledge on mountain east of Hotsprings, elev. 3,200 feet, specimens with young fruits on June 26, No. 22229. Apparently a first record for British Columbia.

Dryas sylvatica is endemic to the interior Alaska-Yukon plateau ranging north to the Mackenzie Delta and east to the edge of the Precambrian Shield.

Fragaria yukonensis Rydb.

For discussion of *F. yukonensis* see Hult. (1946, p. 1008), and Porsild (1951, pp. 220-221). Common on grassy slope on mountains east of Hotsprings. Specimens collected on the upper slope at 3,000 feet elev., No. 22230, were noted to differ from those at the foot of the mountain, No. 22231, by having consistently larger leaves that were more densely hirsute on the underside of the leaflets and on the petiole. In both, the expanded flowers were small, measuring about 1 cm in diameter. An endemic of southern Yukon, not previously recorded from British Columbia.

***Geum macrophyllum* Willd. ssp. *perincisum* (Rydb.) Hult.**

Common near Hotsprings in rich woods, No. 22061, where it was collected in 1944 (Porsild, No. 9083). *G. macrophyllum*: from E. Asia across N. America, from S. Alaska to Labrador south to Oregon, the Great Lakes, New Hampshire, and Nova Scotia. The ssp. *perincisum* is of more continental and northern range, from central Alaska to Hudson Bay north to the treeline.

***Potentilla arguta* Pursh ssp. *Convallaria* (Rydb.) Keck**

Cordilleran foothill species common locally in open aspen woods on grassy lower slope of mountain east of Hotsprings, elev. 2,500 feet, No. 22232. The Liard station closes a large gap between the isolated population in S.W. Yukon and the southern Canadian Rocky Mts. of Alberta and British Columbia.

***Potentilla diversifolia* Lehm. var. *glaucophylla* Lehm.**

Although not collected in the Hotsprings area, this Cordilleran plant occurs along the Alaska Highway south and west of the hot springs.

***Potentilla fruticosa* L.**

Common in calcareous bogs, flowering specimens on June 25, No. 22062. Wide-ranging circumboreal species in N. America, ranging north a short distance beyond the limit of trees.

***Potentilla furcata* Porsild, Nat. Mus. Canada Bull. 121: 224-25, tab. xviii, fig. 1-4 (1951).**

P. quinquefolia Rydb. in Mem. Dept. Bot. Columbia Univ. 2: 76 (1898), *nomen confusum*.

One colony of specimens in beginning anthesis on rocky outcrops on dry, grassy slope of mountain east of Hotsprings, elev. 3,000 feet, No. 22237. The species thus far was known only from southern Yukon and from a couple of stations in Banff National Park, Alberta, where in recent years a number of additional collections have been made. Rydberg's excellent illustration (l.c. tab. 30), showing a flowering specimen of *P. furcata*, was probably drawn from Macoun, No. 7291, "Lower Bow flats, National Park, Rocky Mts.," which probably is in the vicinity of Banff. Rydberg did not designate a type for his *P. quinquefolia* and among the other collections cited by him only one other, "Saskatchewan: E. Bourgeau, 1857-8" represents typical *P. furcata*. A duplicate of the Bourgeau collection is in Kew. The printed label is that of "Palliser's Brit. N. Am. Expl. Expedition. . . . coll. E. Bourgeau 1857-8." On the label the word "Saskatchewan" has been crossed out and "Rocky Mountains" inserted in ink. In the same hand (probably of W. J. Hooker) is added: "*P. rubricaulis*? Lehm."

The Bourgeau specimen, of which I made a photograph, is that of a fruiting specimen and undoubtedly was collected in what is now Banff National Park, Alta.

Among the other specimens cited by Rydberg under *P. cinquefolia*, "Alberta: John Macoun, No. 16721, 1897" is a perfect match for another Macoun collection, No. 16735, correctly cited by Rydberg (l.c. p. 84) under *P. Hookeriana* Lehm.

Potentilla furcata is a Cordilleran foothill species thus far known from a small number of widely scattered stations from S.E. Yukon, northern British Columbia, Alberta, Saskatchewan to western Manitoba.

***Potentilla Ledebouriana* Porsild**

Noted but once, on rocky ledge of mountain east of Hotsprings, elev. 3,200 feet, No. 22233. Fruiting on June 26.

Cordilleran – E. Asiatic species.

***Potentilla nivea* L. ssp. *Hookeriana* (Lehm.) Hiit.**

Mountain east of Hotsprings, specimens with fully mature fruits, on stony scree, elev. 2,500 feet, No. 22235; flowering specimens on rocky ledges, elev. 3,200 feet, No. 22234; both on June 26. Amphi-Beringian geographic race, ranging from the western Canadian Arctic Archipelago south through mountains of Alberta.

***Potentilla pennsylvanica* L.**

P. pennsylvanica var. *strigosa* Pursh, not *P. strigosa* Pall.

Common on rocky scree slope of mountain east of Hotsprings, flowering specimen on June 26, No. 22236. Our plant belongs in a western or Cordilleran race that, if treated as a distinct species, should be called *P. missourica* Hornem. (Fern. in Rhod. 37: 286–92, 1935).

***Prunus pennsylvanica* L.**

Occasional and local on a sliderock slope on mountain east of Hotsprings; low, erect bushes, flowering sparingly on June 26, No. 22238. Wide-ranging woodland species reaching S.W. Mackenzie and N.E. British Columbia but thus far not collected in Yukon or Alaska.

***Prunus virginiana* L.**

Occasional in openings in rich woods near springs where bushes 8 to 12 feet tall flowered on June 24 and 25. Collected here in 1944 (Porsild, No. 9084). Collections by Anderson & Brown, No. 8989, have been reported from here by Hultén (1950) as *P. melanocarpa* (Nels.) Rydb. In our Liard Hotsprings material the young twigs and the underside of the thin, fresh green leaves are perfectly glabrous, as is also the case with the bulk of specimens of choke cherries from Western Canada, many of which in the National Herbarium are labelled *P. melanocarpa* or *P. demissa* (Nutt.) Dietr. The latter species is said to differ from *P. virginiana* L. by its pubescent young twigs and pale green leaves of a firmer texture, and pubescence on the underside. I can see no consistent difference between our Liard material and typical eastern *P. virginiana*.

Wide-ranging forest species from Newfoundland to British Columbia, in the Northwest reaching northern British Columbia but not Yukon or Alaska. Liard Hotsprings is thus considerably beyond the continuous range of the species, its nearest known stations being the upper Peace R., B.C., and McMurray on the lower Athabasca, Alta.

Rosa acicularis Lindl.

Common in openings in the forest where, near the hot springs, flowering bushes up to 8 feet tall were noted, No. 22065. First collection here in 1944 (Porsild, No. 9085). In clearings and along roadsides in the Hotsprings area we noted a form of *R. acicularis* with deep reddish-purple petals, No. 22066. It grew together with the typical pink-flowered plant, from which it does not differ in other respects. Wide-ranging circumboreal forest species.

Rosa Woodsii Lindl.

Common on sliderock on mountain east of Hotsprings, elev. 2,500 feet, where it formed low thickets, and flowered on June 26, No. 22239.

Cordilleran foothill species reaching into S.W. Mackenzie, southern Yukon, and central Alaska. Near its northern limit perhaps always restricted to favoured habitats.

Rubus acaulis Michx.

Common on hummocks in black spruce bogs near hot springs, flowering on June 28, No. 22067. N. American boreal forest species, wide-ranging from Labrador to central Alaska.

Rubus arcticus L.

Occasional in white spruce bog, flowering on June 25, No. 22069. Amphi-Beringian species extending through Alaska-Yukon into northern British Columbia.

Rubus pubescens Raf.

Common in rich woods near hot springs, flowering on June 24, No. 22070. Collected here in 1944 (Porsild, No. 9087).

Wide-ranging N. American boreal forest species extending to central Yukon but not reaching Alaska.

Rubus strigosus Michx.

Occasional in openings in forest and by roadside clearings, flowering on June 25, No. 22071. Wide-ranging boreal forest species extending from Newfoundland to Alaska.

Sorbus scopulina Greene

A few tall bushes in rich woods near hot springs. Flowering specimens were collected on June 16, No. 22072, and some with young fruits on June 25, No. 22073. Specimens in beginning anthesis collected here on June 2, 1944 (Porsild, No. 9086). Wide-ranging Cordilleran species extending through Alberta, British Columbia, and S. Yukon to S. and central Alaska.

LEGUMINOSAE

Astragalus alpinus L.

Not seen or collected in the vicinity of hot springs but noted as common on river-bank terraces near Liard Crossing. Circumpolar, arctic-alpine.

Astragalus eucosmus Robins.

Occasional on grassy slopes of mountain east of Hotsprings between 2,000 to 3,000 feet elev., flowering on June 25, No. 22240. N. American wide-ranging, subarctic species.

Hedysarum alpinum L. var. **americanum** Michx.

Although not actually noted in the Hotsprings area, this species is common in rich spruce woods along the highway immediately south and west of Liard Crossing. Wide-ranging N. American boreal forest species.

Hedysarum Mackenzii Richards.

Common on gravelly floodplains near Liard Bridge, No. 22777. Wide-ranging from E. Asia across subarctic N. America to Hudson Bay with disjunct areas in the Gulf of St. Lawrence, extending south in mountains through British Columbia and Alberta.

Lathyrus ochroleucus Hook.

Rather common in rich open woods near hot springs, flowering on June 22, No. 22074. N. American woodland species extending from British Columbia to W. Quebec, and in the West north to Mackenzie District but as yet not reported from Yukon or Alaska.

Lupinus arcticus Wats.

Common locally on grassy slope of mountain east of Hotsprings, elev. 3,000 feet, flowering specimens with young fruits on June 26, No. 22242. On the same slope we noted colonies of a strikingly hairy form, easily spotted from a distance by the distinctly paler appearance of the plant owing to long pubescence of the stems, peduncles, calyces, petioles, and underside of the leaflets. In addition, the front of the standard that in typical *L. arcticus* is creamy white appeared distinctly yellow in the hairy form, No. 22241.

Along the Alaska Highway and access roads through S.E. Yukon and northernmost British Columbia, *Lupinus arcticus* in recent years has invaded embankments and areas of disturbed soil where it tends to become a weedy pioneer species.

Endemic of arctic-alpine N.W. America.

Oxytropis gracilis A. Nels.

Common in open willow thicket on river terraces west of Liard bridge, No. 22278. Flowering specimens on June 28. Tending to become weedy by roadsides and in recently disturbed soils.

Cordilleran foothill species extending north through the Canadian Rockies to Yukon, Alaska, and the Mackenzie, and eastward to Manitoba.

Oxytropis retrorsa Fern. var. **sericea** (T. & G.) Fern.

Common in open willow thickets or river terraces west of Liard Bridge, No. 22279. Specimens with flowers and well-formed fruits on June 28.

Cordilleran race with a similar range as preceding.

Oxytropis spicata (Hook.) Standl.

O. campestris (L.) DC. var. *spicata* Hook. Fl. Bor.-Am. 1: 147 (1834).

South-facing mountain east of Hotsprings. Fruiting specimen collected on June 26 on sliderock slope at 2,000 feet elev., No. 22244; higher up, on grassy slopes the species was in full flower, No. 22243. Our specimens are a perfect match for Raup and Abbe, No. 3553, from dry bluff on north bank of Peace R. at Taylor Flats, B.C., listed by Raup (1934 and 1947) as *O. spicata* Hook. Two other Peace R. collections (Raup & Abbe, Nos. 3980 and 3844) by Raup (l.c.) are referred to *O. saximontana* A. Nels, but the determination was later (Raup, 1942) changed to *O. Paysoniana* A. Nels. Barnaby (1952) only cites Raup & Abbe, No. 3844, which he considers to be *O. sericea* Nutt. var. *spicata* (Hook.) Barnaby. *O. Paysoniana* A. Nels. is considered by Barnaby a synonym of *O. campestris* (L.) DC. var. *Cusickii* (Greenm.) Barnaby. The three Raup & Abbe numbers clearly are conspecific and with our Liard collections should be referred to *O. spicata* (Hook.) Standl.

Cordilleran foothill species, in Canada ranging from interior British Columbia eastward to Manitoba north to the upper Liard (B.C.) and S.W. Mackenzie.

Oxytropis splendens Dougl.

Common on grassy slopes of mountain east of Hotsprings; specimens in beginning anthesis, June 26, No. 22245.

Cordilleran foothill species, in Canada extending northward, east of the Continental Divide, to Yukon and Alaska eastward into Mackenzie, Saskatchewan, Manitoba, to N. W. Ontario.

Vicia americana Muhl.

Flowering specimens on June 24 in open woods near hot springs, No. 22075, where I collected it in 1944 (Porsild, No. 9088).

Boreal forest species ranging from British Columbia and southernmost Alaska east to W. Quebec, northward along the Mackenzie valley beyond the Arctic Circle.

GERANIACEAE

Geranium Bicknellii Britt.

Common along roadsides and in clearings by public campgrounds where it was first collected in 1944 (Porsild, No. 9093) and where it obviously is a recent introduction.

N. American wide-ranging species of weedy habit, doubtfully native in Yukon and Alaska where it is rapidly spreading along newly constructed roads and highways.

EMPETRACEAE

Empetrum nigrum L.

Noted as rare in spruce woods, No. 22076. Our specimens were sterile, but a single shrivelled flower bud contained ovary and stamens. Circumpolar, arctic-alpine.

VIOLACEAE

Viola adunca Sm.

Common on grassy slopes of mountain east of Hotsprings, to elevation of 3,000 feet, No. 22246. Our specimens are totally glabrous, as is also the case with Yukon specimens cited by the writer (Porsild, 1951).

Wide-ranging N. American species.

Viola nephrophylla Greene

Common in damp places in the Hotsprings area where it was particularly common in the vicinity of the springs, Nos. 22077 and 22080, and on hummock and tufa ridges in wet marsh below springs, No. 22078, although occasional also in rich woods, No. 22079. First collected here in 1943 (Clarke, No. 79), in 1944 (Porsild, No. 9091) and by Anderson & Brown, No. 9885 (Hult., 1950). On June 24, 1960, and also in 1944, the species had fully expanded flowers; in 1944 when the season was about three weeks earlier, *V. nephrophylla* flowered on June 2.

Wide-ranging N. American woodland species, extending in Canada from British Columbia to Newfoundland; in the Mackenzie disjunct on Great Bear River.

Viola renifolia Gray var. *Brainerdii* (Greene) Fern.

Occasional in rich spruce woods, Nos. 22081-2. Our specimens had opened and already had empty capsules on June 25; both are typical *V. renifolia* var. *Brainerdii* (See also Porsild, 1951). First collected here in 1944 (Porsild, No. 9089). Similar range as preceding.

Viola rugulosa Greene

Common in rich woods near Hotsprings, No. 22083. Flowering specimens on June 24. First collected here in 1943 (Clarke, No. 80), also Porsild, No. 9090, and by Anderson & Brown, No. 9910 (Hult., 1950).

Western woodland species.

ELAEAGNACEAE

Shepherdia canadensis (L.) Nutt.

Occasional in openings in spruce woods; specimens with young fruits on June 25, No. 22084.

Wide-ranging N. American boreal forest species.

Elaeagnus commutata Bernh.

Common on dry scree of mountains east of Hotsprings; specimens with young fruits on June 26, No. 22247.

Wide-ranging N. American prairie and grassland species extending from central Alaska to S.W. Quebec; isolated in Gaspé, P.Q.

ONAGRACEAE

Circaea alpina L.

Common in wet places close to hot springs, No. 22085. Wide-ranging, circumboreal forest species, at its northern limit restricted to favoured habitats such as warm springs.

Epilobium angustifolium L.

Noted as common in openings and clearings in Hotsprings area; river-banks, No. 22280. Circumboreal woodland species.

Epilobium glandulosum Lehm. var. **adenocaulon** (Hausskn.) Fern.

Very common in wet places near the springs and in the wet marshy areas below, not yet flowering on June 24, No. 22087. A second collection, in wet places by a cold brook, No. 22086, although clearly belonging in the *E. glandulosum* var. *adenocaulon* complex, has dark purple stems, and leaves strongly suffused with purple, 3 to 5 cm long and 0.8 to 1.0 cm. broad, broadest below the middle. On June 30, when *E. glandulosum* var. *adenocaulon* near the hot springs was still without flowers, No. 22086 already had flowers and well-formed young fruits. It rather closely agrees with a series collected in 1944 in S.E. Yukon, and with some hesitation referred by the writer (Porsild, 1951, p. 255) to var. *perplexans* Trel. in Mo. Bot. Gard. 2nd Ann. Rept. 96 (1891) Tab. 25.

Wide-ranging N. American forest species extending from central and southern Alaska east to Newfoundland and southern Labrador.

Epilobium leptophyllum Raf.

Margin of warm pool. Raup and Correll, No. 10880.

HIPPURIDACEAE

Hippuris vulgaris L.

In a cool pond in woods west of Liard Post, No. 22298. Wide-ranging, circumboreal.

ARALIACEAE

Aralia nudicaulis L.

Common in rich aspen woods near the springs, No. 22088, where it was first collected in 1944 (Porsild, No. 9095) and by Anderson & Brown, No. 9881 (Hult., 1951). Common also in open aspen forest on south-facing slopes of mountain east of Hotsprings, No. 22248.

N. American woodland species extending from British Columbia to Newfoundland, south to Georgia and west to Colorado and Idaho.

UMBELLIFERAE

Cicuta Douglasii (DC.) Coult. & Rose

Common in springy places below the springs where the first flowers were opening on June 24, No. 22089. Previously collected by Anderson & Brown, No. 9875 (Hult., 1951). A western species extending from central and southern Alaska south to California east to Great Slave L. and Alberta.

Heracleum lanatum Michx.

Very common in rich damp soil near the hot springs and in open glades in rich forest; specimens with flowers and well-formed fruits on June 25, No. 22090. Specimens collected here on June 2, 1944, were as far advanced. Wide-ranging forest species, in N. America from Newfoundland to Alaska. Also E. Asia.

***Osmorhiza obtusa* (Coult. & Rose) Fern.**

Common in rich woods near the springs; specimens with well-formed young fruits on June 24, No. 22091. First collected here in 1944 (Porsild, No. 9094), and in 1946 by Anderson & Brown, No. 9882 (Hult., 1950). The Hotsprings station constitutes a considerable extension of the range of this wide-ranging forest species, its nearest known stations being in the upper Peace R. district (Raup, 1934) and in the Alaska Panhandle.

***Sanicula marilandica* L.**

Common in rich woods by hot springs, flowering on June 24, No. 22092. First collected here in 1943 by Clarke, Nos. 81 and 82; in 1944, by Porsild, No. 9096, and in 1946 by Anderson & Brown, No. 9886 (Hult., 1950). The nearest known station for this wide-ranging N. American woodland species is on the upper Peace R. (Raup, 1934).

CORNACEAE

***Cornus canadensis* L.**

Very common in spruce woods, flowering on June 25, No. 22093. Wide-ranging N. American forest species reaching E. Asia.

***Cornus stolonifera* Michx.**

Common in openings in rich woods; tall bushes in flower on June 24, No. 22094. In open aspen woods on mountain slopes east of Hotsprings, elev. 2,500 feet, No. 22250. Both collections are the var. *Baileyi* (Coult. & Evans) Raup. Wide-ranging N. American forest species. The var. *Baileyi* appears to be a western and inland race.

PYROLACEAE

***Moneses uniflora* (L.) Gray**

Common in cool, mossy spruce woods, No. 22095. Wide-ranging circumboreal forest species.

***Pyrola asarifolia* Michx. var. *purpurea* (Bge.) Fern.**

Common in rich woods, Nos. 22096-7, and on hummocks, in open *Larix* bog, No. 22098. Also collected here in 1944, Porsild, No. 9097; Anderson & Brown, No. 9907 (Hult., 1950). Wide-ranging nearly circumboreal forest species.

***Pyrola grandiflora* Rad.**

Common among willows and on gravelly river terrace west of Liard Bridge, No. 22281. Circumpolar, wide-ranging arctic-subarctic species. The Hotsprings station is near the southern limit of the continuous range of the species.

***Pyrola secunda* L.**

Common in rich spruce woods, No. 22099 (var. *typica*). Wide-ranging circumboreal forest species.

***Pyrola virens* Schweigg.**

In aspen – *Salix Scouleriana* thicket in moist ravine on mountain east of Hotsprings, elev. 3,000 feet, No. 22249. In cool spruce woods west of Liard Post, No. 22299. Circumboreal, wide-ranging forest species.

ERICACEAE

***Ledum groenlandicum* Oed.**

Common in boggy spruce woods, No. 22101, and noted in *Larix* bog below springs. Wide-ranging N. American forest bog species.

***Arctostaphylos rubra* (Rehd. & Wilson) Fern.**

Occasional in damp spruce woods, No. 22100. Wide-ranging, calciphilous species of N. America and E. Asiatic subarctic.

***Arctostaphylos Uva-ursi* (L.) Spreng. var. *adenotricha* Fern. & McBr.**

Noted as local in dry spruce woods on tufa ridge. Wide-ranging almost circumboreal woodland species.

***Oxycoccus microcarpus* Turcz.**

Common on sphagnum hummocks in black spruce bog, No. 22102. Wide-ranging, nearly circumboreal woodland bog species but in N. America clearly a western type.

***Vaccinium Vitis-idaea* L. var. *minus* Lodd.**

In aspen – *Salix Scouleriana* thicket in a damp ravine on mountain east of Hotsprings, elev. 3,000 feet, No. 22251, flowering on June 26. Wide-ranging, circumboreal.

PRIMULACEAE

***Androsace septentrionalis* L.**

Common on dry, grassy slopes of mountain east of Hotsprings; 33-cm-tall specimens that on June 26 had matured seeds, No. 22252. In N. America several races, the interrelation and ranges of which are not well understood.

***Dodecatheon pauciflorum* (Durand) Greene**

A single flowering specimen, No. 22103, was collected near the present Liard R. bungalow camp. According to the proprietor, Mr. J. E. Parsons, several plants appeared in a flower bed for which soil had been hauled from a near-by meadow. We did not see this species elsewhere in the Hotsprings area, nor did we succeed in finding additional specimens. In its natural habitat, *Dodecatheon pauciflorum* flowers early, and as Mr. Parsons could not indicate the exact place from which the soil had been taken, we may not have searched for it in the same meadow or perhaps we may have overlooked fruiting specimens. A Cordilleran species which in the Mackenzie Basin extends north to Slave Lake (Raup, 1947); west of there it is known from a single collection in the Dawson area, Y.T., and from a single Alaskan collection, "Between Ft. Yukon and La Pierre House, McTavish" (CAN).

Lysimachia thyrsiflora L.

Rather local in a wet marsh below the springs, growing among *Scirpus validus* and *Cicuta Douglasii*; flowering specimens on June 28, Nos. 22104-5. The Hotsprings' station closes a 1,000-mile gap between its nearest known station: Gt. Slave Lake, N.W.T., and Haines on the Pacific Coast of Alaska. Wide-ranging circumboreal woodland marsh species.

Primula mistassinica Michx.

Very common on calcareous hummocks in *Larix* bog below the springs; flowering on June 16, No. 22106, and on wet calcareous tufa cliffs near springs, No. 22107, where it was first collected in 1944 (Porsild, No. 9098). N. American species of calcareous woodland fens, wide-ranging from Newfoundland to the Mackenzie, with isolated stations in Yukon, and barely reaching Alaska.

GENTIANACEAE

Gentiana acuta Michx. *G. Amarella* L. s. lat.

Common in open willow thickets on river terrace west of Liard Bridge, not yet in flower on June 28, No. 22282. Wide-ranging grassland species of wooded parts of boreal N. America reaching eastern Asia.

Gentiana propinqua Richards.

Although not noted or collected in the Hotsprings area, *Gentiana propinqua* was noted as common along the Alaska Highway south and west of Liard Crossing. A specimen collected south of the Crossing is in the National Herbarium (Rand, No. 31). Wide-ranging subarctic species ranging from easternmost Asia over Alaska, Yukon, and Mackenzie to Hudson Bay. Isolated in Gaspé, Newfoundland, and southern Labrador.

APOCYNACEAE

Apocynum androsaemifolium L.

Local in dry spruce woods on tufa ridge near the springs; specimens in early florescence, No. 22108. The species was collected here in 1944 (Porsild, No. 9101) and by Anderson & Brown, No. 9896 (Hult., 1948). Wide-ranging N. American woodland species ranging from Newfoundland to British Columbia north to southern Mackenzie, southern and central Yukon and Alaska but not reaching Bering Sea. In the Northwest apparently rare and restricted to thermally favoured stations, such as hot springs and south-facing slopes.

POLEMONIACEAE

Polemonium pulcherrimum Hook.

A Cordilleran plains and foothills species ranging from Alaska over Yukon to the Mackenzie Delta and Gt. Bear Lake, south through mountains of Alberta and British Columbia to California, east to Idaho and Wyoming. Although not noted or collected in the immediate vicinity of the Hotsprings, it occurs sporadically west and south of the area.

In 1944 I noted that in southeastern Yukon *Polemonium pulcherrimum* was "common on dry sandy or gravelly places on calcareous schists and shales on the Lewes and Pelly Rivers and in the north end of Rose-Lapie Pass" (Porsild, 1951). Since 1944, *Polemonium pulcherrimum* has spread along the Alaska Highway at a phenomenal rate; it now grows in great profusion on road shoulders and road embankments, specially on the soils derived from sedimentary or volcanic rocks of the interior Yukon plateau; during the month of June, in 1960, for a distance of more than two hundred miles between Whitehorse and Teslin, its masses of purple flowers literally coloured the shoulders of the Alaska Highway.

HYDROPHYLLACEAE

Phacelia Franklinii (R. Br.) Gray

Noted by roadsides on the public campsite where it is a recent introduction. A native species which tends to become weedy and is common by roadsides along the Alaska Highway. Wide-ranging N. American western species of open woodlands, extending northward into southern Mackenzie, Yukon, barely reaching central interior Alaska.

BORAGINACEAE

Cynoglossum boreale Fern.

Local in open spruce woods on dry tufa ridge near the springs, flowering on June 24, No. 22110; fruiting specimens in rich herbmats at base of tufa dome below the springs, June 29, No. 22109, where it was collected in 1943 (Clarke, No. 87) and in 1944 (Porsild, No. 9100). Hultén (1949) reporting an Anderson & Brown collection, No. 9884, remarks "This plant was certainly introduced into our area." As noted by Fernald (1905) *Cynoglossum boreale* is "of wide range" and is "usually growing in spruce woods." The Liard R. habitat for *Cynoglossum boreale*, six degrees of latitude north of the northernmost British Columbian station known to me (Prince George, lat. 63° N.), is quite undisturbed and in virgin spruce forest; there is no reason for assuming that *Cynoglossum* is not indigenous there.

Wide-ranging N. American woodland species of peculiar local and spotty distribution from New York, New Hampshire, and Maine, north to Newfoundland and James Bay, west to Manitoba, then disjunct in interior British Columbia.

Mertensia paniculata (Ait.) G. Don.

Abundant in openings in rich spruce woods, flowering on June 25, No. 22111; first collected here in 1944 (Porsild, No. 9099). Wide-ranging N. American woodland species which tends to become weedy in clearings and on roadsides along the Alaska Highway. From Alaska eastward over Yukon and southern Mackenzie east to James Bay, south to Ontario, Michigan, Wisconsin, Minnesota, and Iowa, Saskatchewan, Alberta, British Columbia south to Montana, Idaho, and Washington. Probably also in E. Asia.

LABIATAE

Dracocephalum parviflorum Nutt.

Flowering specimens on June 28 on river terrace west of Liard Bridge, No. 22283. Wide-ranging N. American species of river-banks, floodplains, and open places, from E. Quebec to British Columbia, Yukon and central Alaska south from Arizona to New York.

Mentha arvensis L.

Hultén (1943) reports an Anderson & Brown collection, No. 10373, from Liard Hotsprings. We did not see this species.

Wide-ranging woodland species of wet river-bank meadows ranging from Alaska to Newfoundland. Near its northern limit in the Northwest limited to the vicinity of hot springs or similarly favoured habitats where it is represented mainly by var. *villosa* (Benth.) S.R. Stewart (*M. canadensis* (L.) Briq.)

Scutellaria epilobiifolia Ham.

Wet openings in rich woods. Raup and Correll, No. 10892.

SCROPHULARIACEAE

Castilleja Raupii Pennell

Local in open spruce forest on dry calcareous tufa cliffs below hot pool, flowering on June 29, No. 22112; 60-cm-tall flowering specimen on grassy mountain slope east of Hotsprings, elev. 3,200 feet, No. 22253.

Wide-ranging across Canada from the Yukon-Alaska border to the west coast of Hudson Bay. Thus far, nearly all known stations are from near the northern limit of the boreal forest.

Mimulus guttatus DC.

Common, but found only in close proximity to hot springs where it generally grew by the edge of pools measuring 38° C. or over. Flowering specimens with young fruits collected on June 24, No. 22114. A wholly submersed sterile form with very small leaves and abundant root development from the nodes was noted in a cool pool (21° C.), No. 22113. Collected at the Hotsprings in 1943 by Clarke, No. 88, and in 1946 by Anderson & Brown, No. 9879 (Hult., 1949). *Mimulus guttatus* is a denizen of the moist Pacific coast flora and in its few interior stations, far from the coast, is restricted mainly to warm springs or to local areas that, owing to topographic features, have heavy precipitation; the species through the Crowsnest Pass thus reaches southern Alberta, with a widely disjunct station in Cypress Hills, Sask., but thus far has not been found in Banff or Jasper Parks. The nearest known inland station to Liard Hotsprings is on the upper Peace R. where Raup (1934) reported it from "springy slope of river bluff" at Hudson Hope, B.C.

Penstemon Gormanii Greene

Common on dry grassy mountain slope east of Hotsprings, where the species flowered at 3,000 feet on June 26, No. 22254. An endemic of the dry

interior plateau of eastern Alaska and southern Yukon. The Liard station, which is the first for British Columbia, extends the known range of *P. Gormanii* slightly to the East.

***Veronica americana* Schwein.**

Common locally but found only in proximity to hot springs; flowering specimens on June 24 in wet mud by the edge of pool, No. 22115. Wide-ranging from E. Asia across southern and central Alaska, across Canada well south of the treeline to Newfoundland. Near its northern limit mainly at hot springs and in thermally favoured habitats.

OROBANCHACEAE

***Boschniakia rossica* (Cham. & Schlecht.) B. Fedtsch.**

Although well within its range, we failed to discover this curious species in the Hotsprings area. Inasmuch as it has been reported from adjacent parts of S.E. Yukon (Porsild, 1951) and from the Alaska Highway not far south of Liard Crossing (Muncho Lake, Rand, No. 10, CAN), *Boschniakia* likely will be discovered near the Liard Hotsprings. The Muncho Lake specimen, incidentally, is the first authentic record of this species from British Columbia, inasmuch as Hultén (1949) erred in assuming that *B. strobiliacea* Gray, cited in Henry's *Flora of S. British Columbia*, is identical with *B. rossica*. *B. strobiliacea* Gray, for which an earlier name, *B. tuberosa* (Hook.) Jepson is available, is a native of California and barely reaches the west coast of British Columbia. It is parasitic on *Arctostaphylos* spp., *Arbutus Menziesii*, and *Gaultheria Shallon*. Henry (l.c.) noted that it is eaten by Indians, who call it "Poque." The N. American range of *Boschniakia rossica* is from Bering Strait east to Mackenzie Delta, Gt. Bear Lake, Slave Lake south to Lake Athabasca, northernmost British Columbia, and the Alaska Panhandle.

LENTIBULARIACEAE

***Pinguicula vulgaris* L.**

Common on calcareous tufa terraces near hot springs and by the pools; flowering specimens and some with young fruits were collected on June 25, No. 22116; common on hummocks in calcareous bogs below Hotsprings, No. 22117. As noted (Porsild, 1951), *Pinguicula vulgaris* was not encountered by him in S.E. Yukon, nor has it as yet been collected elsewhere in Yukon Territory, despite the presence there of suitable habitats and despite the fact that collections are known from adjacent parts of Alaska, British Columbia, and Mackenzie District. The range given by Hultén (1949) "Alaska and Yukon over lower Mackenzie, etc." is thus incorrect and not in agreement with his map on p. 1473, which shows no dots in Yukon Territory. Circumboreal, wide-ranging, mainly in calcareous fens, north beyond the timberline.

***Utricularia intermedia* Hayne**

Sterile specimen collected at the hot springs in 1943, Clarke, No. 89 (Porsild, 1951), Anderson & Brown in 1946 (Hult., 1949).

Circumboreal, wide-ranging, in N. America from Newfoundland to Bering Strait, north to or slightly beyond the treeline; in W. Greenland north to lat. 72°; south to California, Indiana, and New York.

Utricularia ochroleuca Hartm.

Common in shallow pools or ponds below the springs, growing in water measuring 16° to 21° C., sterile specimens on June 24, No. 22118. Likewise sterile specimens collected here in 1944 (Porsild, 1951).

Utricularia ochroleuca, sometimes considered a hybrid (*U. intermedia* x *U. minor*), otherwise is known from widely scattered stations in Atlantic parts of Europe and W. Greenland. Since first reported from the North American Continent, on St. Paul Island in the Gulf of St. Lawrence (Perry, 1931), its known North American range has been extended across the Continent to British Columbia (Porsild, 1951) and Alaska (Drury, 1956), and north to the Arctic Coast (Porsild, 1943). Its Canadian range appears to be slightly more boreal than that of *U. intermedia*, although it is sometimes associated with that species. Thus far, I have seen only sterile specimens from North America. The following N. American collections are in the National Herbarium of Canada.

W. Greenland: N. Strømfjord, Sarfarssuaq, lat. 67°49' N., M. P. & A. E. Porsild; Arfersiorfik Fj., Sofias Havn, lat. 68°20' N., 51°5' W., M. P. Porsild; Ikerasak, Umanaq Dist. lat. 70°29' N., M. P. Porsild. Quebec: Saguenay Co., Natashquan, 1927, H. F. Lewis; Ft. Chimo, Ungava, 1896, Spreadborough; Port Harrison, Polunin, No. 1775; Cape Jones, Baldwin, Hustich, Kucyniak and Tuomikoski, No. 1075. Ontario: Mouth of Black Duck R., south shore of Hudson Bay, Moir, No. 2260. Manitoba: Churchill, Polunin, No. 2063; D. K. Brown, No. 341. British Columbia: Liard Hotsprings (cited above). Northwest Territories: Gt. Bear Lake, north shore of Smith Arm, A. E. & R. T. Porsild, No. 5015; McTavish Arm, Hunter B., H. T. Shacklette, No. 3273 (in part); Sawmill Bay, Leith Pen., *idem*, No. 2975 (in part) and No. 3082 (in part); Mackenzie Delta, Richards Island, Porsild, No. 7076.

Utricularia vulgaris L. var. *americana* Gray

U. macrorhiza LeConte

In shallow pond below springs, sterile specimens on June 24, in water measuring 21° C., No. 22119.

Wide-ranging N. American species (or race of *U. vulgaris*).

PLANTAGINACEAE

Plantago major L. var.?

Common on river-bank terraces west of Liard Bridge, No. 22284. Our plant belongs in a race of *P. major* which is common on calcareous river-banks and lake shores and obviously indigenous across boreal N. America from central Alaska through central Yukon and the lower Mackenzie Basin eastward at least to James Bay south into Alberta, Saskatchewan, and northern Ontario. Its taxonomic status is as yet unclear,

although it seems certain that it is not *P. asiatica* L. or *P. major* var. *asiatica* (L.) Dene. (Raup, 1947; Hult., 1949). Fernald (Gray's Man., 1950), for what likely is this plant, has taken up *P. major* var. *Pilgeri* Domin.

RUBIACEAE

***Galium boreale* L. s. lat.**

Common on grassy slope of mountain east of Hotsprings, No. 22255. Collected near the springs in 1944 (Porsild, No. 9104). Circumboreal. Wide-ranging from Bering Strait to Nova Scotia.

***Galium trifidum* L.**

Among tall sedges by a pond west of Liard Post, No. 22300; common in wet places in calcareous *Larix* bog below the springs, flowering on June 24, No. 22120. Circumboreal, in N. America from Bering St. to Newfoundland north to the limit of trees.

***Galium triflorum* Michx.**

Common in rich woods near the springs; specimens not yet flowering on June 24, No. 22121. Earlier collections are Clarke, 1943 (No. 90) and 1944 (Porsild, No. 9103). Wide-ranging woodland species of rich forests, near its northern limit always restricted to thermally favoured habitats.

CAPRIFOLIACEAE

***Linnaea borealis* L. var. *americana* (Forbes) Rehd.**

Common everywhere in dry spruce woods; flowering specimens on June 24, No. 22122. N. American race, wide-ranging from Alaska to Newfoundland and W. Greenland, in Canada north to the limit of trees.

***Lonicera glaucescens* Rydb.**

Common in rich woods, No. 22123; flowering specimens in open aspen woods on mountain east of Hotsprings, No. 22256; collected at the springs in 1944 (Porsild, No. 9105) and reported from there by Hultén (1949). The station appears to be the most westerly in Canada. A foothills and plains species endemic to central Canada and adjacent states of the U.S.A.

***Viburnum edule* Raf.**

Common in rich woods, and collected here in 1944 (Porsild, No. 9106). Wide-ranging N. American woodland species.

ADOXACEAE

***Adoxa Moschatellina* L.**

Common locally by a brook east of main hot springs area in rich leaf mould among *Urtica gracilis* and *Heracleum lanatum* in open aspen woods; flowering and fruiting on June 30, No. 22124.

Circumboreal species of peculiar and spotty distribution, in Canada thus far not collected east of Lake Winnipeg, although south of the U.S.

border known from a few stations in the East. Recent additional collections from the upper Mackenzie drainage are now bridging the apparent gap between Alaska and Yukon in the Northwest and central and south British Columbia and Alberta.

CAMPANULACEAE

Campanula aurita Greene

A few specimens were noted growing near the trail leading to the hot springs, on a dry calcareous hummock in open spruce woods, No. 22125. Its rather precarious habitat was called to my attention by Miss W. Steeves, who had observed it here during several years of residence at Liard Post. Common on erosion fan near the Alaska Highway just north of Muncho Lake, B.C., No. 22346. The species is an obligate calciphile endemic to Central Alaska, Yukon, Mackenzie, and northern British Columbia. According to Hultén (1945) closely related to *C. Piperi* of the Olympic Mts., Wash. Apparently not recorded previously for British Columbia.

LOBELIACEAE

Lobelia Kalmii L.

Common locally on tufa walls near the hot springs and less so in similar places by shallow ponds below, and often growing in, soil measuring 32° to 38° C. In such places giant 8- to 10-flowered specimens up to 30 cm tall were collected on June 24, Nos. 22126-7. Collected here in 1946 by Anderson & Brown, No. 10374 (Hult., 1950). N. American species, in Canada wide-ranging from Newfoundland to southern British Columbia with disjunct area in northernmost British Columbia and the upper Mackenzie Basin, N.W.T.

COMPOSITAE

Achillea nigrescens (E. Mey.) Rydb. See Porsild (1951, p. 319)

Common in the Hotsprings area generally, in clearings and by roadsides, flowering on June 25, No. 22128. Wide-ranging in boreal and subarctic N. America from Alaska to Labrador.

Antennaria elegans Porsild, Can. Field-Nat. 64: 18 (1950), map Tab. 3 and fig. 22; *idem*, Nat. Mus. Canada Bull. 121: 314 (1951) Pl. XXXIV.

Common locally, forming small colonies or mats on dry, grassy slope east of Hotsprings; with fully expanded heads on June 26, No. 22257.

Endemic to mountains of S.E. Yukon and western Bear Lake, N.W.T. The present collection extends the known range to northern British Columbia.

Antennaria pulcherrima (Hook.) Greene

Very local on hummocks in rich *Larix* fen below the springs; specimens with fully expanded heads on June 24, No. 22129. First collected here in 1944 (Porsild, No. 107).

Wide-ranging N. American species of calcareous fens and river-banks from Newfoundland to central Alaska.

Antennaria rosea (Eaton) Greene

Flowering specimens on rocky ridge west of Hotsprings, June 30, No. 22130. Wide-ranging species of Western Canada from James Bay to British Columbia north to Mackenzie-Yukon, isolated in S. Alaska; south to S. Dakota.

Arnica alpina (L.) Olin ssp. *angustifolia* (Vahl) Maguire

Summit of mountain ridge east of Hotsprings, elev. 3,200 feet, where it grew in a mat of *Dryas sylvatica*. Flowering heads on June 26, No. 22258.

Wide-ranging N. American arctic race with disjunct area in the southern Canadian Rockies. The present collection extends the known range into northern British Columbia.

Arnica cordifolia Hook.

In moist ravine in an aspen – *Salix Scouleriana* thicket near summit of mountain ridge east of Hotsprings, elev. 3,200 feet, flowering heads on June 26, No. 22259. Cordilleran species reaching southern Yukon and S.W. Mackenzie District.

Artemisia borealis Pall., ssp. *Purshii* (Bess.) Hult.

Occasional on sliderock slope of mountain ridge east of Hotsprings, elev. 3,000 feet, young heads not yet expanded on June 26. Our specimens, as well as the plant of Yukon reported as *A. borealis* (Porsild, 1951), belong in the small-headed western ssp. *Purshii* (Bess.) Hult. Wide-ranging sub-arctic species.

Artemisia frigida Willd.

A dominant species on grassy slopes of mountain ridge east of Hotsprings ascending to 3,000 feet; with not yet formed heads on June 26, No. 22261. Wide-ranging calcareous western species naturalized in E. America. Also in Asia and E. Europe.

Aster alpinus L. ssp. *Vierhapperi* Onno

Common on grassy slopes of mountain ridge east of Hotsprings, elev. 3,000 feet; fully expanded heads on June 26, No. 22262. Cordilleran foothills of S.E. Yukon and Mackenzie District; perhaps not truly disjunct from population in southern Rockies of Alberta. The present collection extends its range into northern British Columbia.

Aster ciliolatus Lindl. *A. Lindleyanus* T. & G.

Not uncommon in openings in rich woods in Hotsprings area; not yet flowering on June 28, No. 22131. Flowering specimens collected in August 1946, Anderson & Brown, No. 10377. Wide-ranging woodland species reaching northern British Columbia and the upper Mackenzie Basin, but not Yukon or Alaska.

Aster junciformis Rydb.

Common in wet places by the edge of hot pools often growing in soil temperatures of over 38° C.; dense clumps, on June 30, when the young

heads were not yet expanded, measured 1 m in height. The roots in our specimens appeared to be annual and fibrous with no trace of rhizome development, Nos. 22132-3.

A wide-ranging N. American woodland species extending north into the upper Mackenzie Basin, central Yukon, and Alaska; near its northern limit probably always limited to springs and specially favoured moist habitats.

Aster modestus Lindl.

Flowering specimens collected August 1, 1946, at Liard Hotsprings, Anderson & Brown, No. 10376 (Hultén, 1950). Not noted by us in June when the species could scarcely have been recognizable.

Western N. American species from S. Alaska and Yukon east to W. Ontario and N. Michigan.

Aster sibiricus L.

Common on dry, grassy slopes of mountain ridge east of Hotsprings, No. 22263; common on river-bank terraces west of Liard Bridge where flowering on June 28, No. 22285.

A wide-ranging arctic-alpine Amphi-Beringian species extending from Alaska-Yukon east into the Mackenzie and south into the Rocky Mountains.

Erigeron compositus Pursh

Common on grassy slopes of south-facing mountain ridge east of Hotsprings at 3,000 feet elev. Fruiting specimens collected on June 26, No. 22264 (var. *discoideus* A. Gray).

N. American arctic species ranging from E. and W. Greenland across the Arctic Archipelago to the Mackenzie District and south through mountains of Yukon, barely reaching S.E. Alaska; with disjunct areas in central Rocky Mountains and in Gaspé, Que.

Erigeron elatus Greene

Common on river-bank terraces west of Liard Bridge, with young fruiting heads on June 28, No. 22286.

N. American wide-ranging boreal forest species.

Erigeron glabellus Nutt. ssp. *pubescens* (Hook.) Cronq.

Common on river-bank terraces west of Liard Bridge; flowering on June 28, No. 22287. Grassy slopes of mountain ridge east of Hotsprings, to 2,500 feet, No. 22265, Anderson & Brown, No. 9845 (Hult., 1948). Wide-ranging Cordilleran prairie and foothill species.

Erigeron philadelphicus L.

Very common in wet places near the hot pools, often in wet soil with temperature up to 42° C. and in one place even to 49° C., No. 22134; flowering specimens on June 24 to 30, No. 22135. First collected here in 1943 (Clarke, Nos. 91 to 93). Wide-ranging from British Columbia to Gaspé, Qué., barely entering the southern fringe of the boreal forest in northern British Columbia and the upper Mackenzie Basin, but thus far not reported from Yukon or Alaska.

Hieracium canadense Michx.

Wet openings in woods. Raup & Correll, No. 10885.

Lactuca biennis (Moench) Fern. *L. spicata* (Lam.) Hitchc.

Only a few plants seen and only in proximity to Hotsprings. Our specimens, lacking flowers and fruits on June 25, were still too young for positive identification. A likewise immature collection (Anderson & Brown, No. 10378) was referred to *L. spicata* (Hultén, 1950). Fully developed fruiting specimens were collected on terrace above Hotsprings on August 25, Raup & Correll, No. 11518.

North American woodland species, wide-ranging from Newfoundland across to British Columbia north to S.E. Alaska, but not reaching Yukon or central Alaska.

Petasites palmatus (Ait.) Gray

Common in rich spruce woods, No. 22137. A wide-ranging N. American boreal forest species ranging from Newfoundland and Labrador west to British Columbia north to the limit of trees; in the Northwest reaching S.E. Yukon but neither the Pacific Coast nor Alaska.

Senecio cymbalarioides Nutt. var. **borealis** (T. & G.) Greene

Common on grassy slopes of mountain ridge east of Hotsprings, flowering specimens at 3,000 feet on June 26, No. 22266. Not present in the Hotsprings area proper. Anderson & Brown, No. 9917 (Hult., 1950). Calciphilous Cordilleran species, ranging north into S.E. Yukon and in the Mackenzie Basin north to Gt. Bear Lake.

Senecio indecorus Greene

A single flowering specimen was collected on June 29 by the edge of a hot pool, No. 22138.

A wide-ranging N. American forest species reaching the upper Mackenzie, central Yukon, and central Alaska.

Senecio pauciflorus Pursh

Not uncommon in boggy places in the Hotsprings area where specimens with expanding heads were collected on June 30, No. 22139. N. American forest species with similar range as the preceding.

Solidago decumbens Greene var. **oreophila** (Rydb.) Fern.

Occasional on grassy slope of mountain ridge east of Hotsprings. Heads not yet fully expanded on June 26, No. 22267. Cordilleran plant of dry foothills and alpine slopes reaching the upper Mackenzie, southern Yukon, and central Alaska.

Solidago lepida DC. var. **elongata** (Nutt.) Fern.

Very abundant near hot springs and their general vicinity where it forms dense colonies, often growing in soil warmed to well above 38° C. First flowering heads noted on June 30, Nos. 22140 to 22144. Wide-ranging

N. American forest plant, reaching its northern limit in the upper Mackenzie Basin, central Yukon, and Alaska where it, perhaps, is always confined to favoured habitats (Porsild, 1939, *idem*, 1951).

***Solidago multiradiata* Ait. var. *scopulorum* Gray**

Common on river-bank terraces west of Liard Bridge, flowering on June 28, No. 22288.

Cordilleran foothill race reaching north to the Mackenzie Delta, Bear Lake, and S.E. Yukon.

***Taraxacum dumetorum* Greene**

Rare and only noted once in moist white spruce forest; specimens with flowering heads on June 28, No. 22144.

Wide-ranging forest specimens from Yukon to James Bay.

BRYOPHYTA

By HOWARD A. CRUM

The bryoflora of the Liard Hotsprings is surprisingly temperate in composition and is, in fact, very similar to that of the Banff and Jasper areas much farther south. So few bryophytes have been collected in northern British Columbia that the species listed below are worthy of note even though their presence there might be, in most cases, easily predicted. Several species are listed as range extensions of unusual interest, however, and include a number of temperate elements from the deciduous forests of eastern North America. *Dicranum flagellare*, *Orthotrichum elegans*, and *Platygyrium repens* are especially common in the East. *Didymodon tophaceus* and *Orthotrichum obtusifolium* are likewise typically temperate, but less characteristically eastern in distribution.

The strongly calcicolous nature of the flora is graphically illustrated by a number of tufa-forming mosses, most notably *Gymnostomum recurvirostrum*, *Didymodon tophaceus*, *Cratoneuron falcatum*, and *Fissidens grandifrons*. Various groups of algae are active in the deposition of lime. The Corallinaceae, for example, are important in the formation of "coral" reefs. Many Dasycladaceae regularly become fossilized by lime encrustation; fossil casts and impressions of their thalli have been dated as far back as the Ordovician. Some of the Charales and many of the smaller green and blue-green algae of fresh waters deposit lime. It is perhaps not generally known that many mosses similarly precipitate calcium carbonate from waters rich in soluble calcium bicarbonate by removing carbon dioxide from solution for use in photosynthesis. Deep deposits of soft limestone, known in the building trade as travertine, can be attributed largely to the tufa-forming activities of mosses.

Many of the bryophytes known from the vicinity of the springs are obligate calciphytes: *Leiocolea badensis*, *Fissidens grandifrons*, *Distichium inclinatum*, *Gymnostomum recurvirostrum*, *Didymodon tophaceus*, *Bryum pendulum*, *Cratoneuron falcatum*, *C. filicinum*, and *Drepanocladus sendtneri* usually—and perhaps always—indicate a calcareous substratum. A number of others, equally common on lime, are apparently less specific in pH preference and often occur in less highly mineralized environments, as well. These include *Riccardia pinguis*, *Bryum pseudotriquetrum*, *Campylium polygamum*, *Tomenthypnum nitens*, *Drepanocladus aduncus*, and *D. vernicosus*; they are characteristic of, but not restricted to fens throughout the Canadian North.

Leiocolea badensis (Gottsche) Joerg. On tufa cliffs, No. 22165; No. 22175 p.p., with *Riccardia pinguis*. Although reported from a wide range (Nova Scotia to British Columbia, southward to New York, Iowa, and Washington), this species seems to be rather rare and local; the only North American specimens in the National Herbarium of Canada are several from Quebec. In Minnesota, according to Schuster's *Manual of Boreal Hepaticae*,

L. badensis is a decided calciphile, growing on moist calcareous cliffs, either as a pioneer or an early invader following colonization by species of *Gymnostomum*. There, as at the Liard Hotsprings, it is commonly associated with *Gymnostomum recurvirostrum* and *Riccardia pinguis* and occasionally *Preissia quadrata*.

Plagiochila asplenoides (L.) Dum. On rotten log, No. 22155 p.p., with *Pleurozium schreberi*.

Riccardia pinguis (L.) S. F. Gray. On tufa cliff, No. 22175.

Preissia quadrata (Scop.) Nees. On hummocks in a shallow pool, marly bog, No. 22145.

Conocephalum conicum (L.) Dum. In overflow area, No. 22120 p.p., with *Galium trifidum*.

Riccia fluitans L. Floating in a quiet brook and in deep, cool pools, 60° to 62°F., Nos. 21928, 22146. Although very widespread throughout the United States and eastern temperate Canada, *R. fluitans* is local and seasonal in occurrence. At the National Herbarium of Canada we have several collections from Ontario and Quebec, but only one from western Canada (Sicamous, British Columbia, Macoun). No mention is made of the Canadian West in the distribution given by Frye and Clark in their *Hepaticae of North America*.

Sphagnum teres (Schimp.) Ångstr. In overflow from a spring, No. 22188.

Fissidens grandifrons Brid. Submerged in water 62° to 66°F., attached to walls and bottoms of pools, Nos. 22167, 22181, 22187.

Ceratodon purpureus (Hedw.) Brid. Beside trail to spring, No. 21970 p.p., with *Carex aenea*.

Distichium inclinatum (Hedw.) BSG. On tufa, No. 22162A.

Dicranum flagellare Hedw. On a rotten log, No. 22180. A very common species of the eastern deciduous forests from Nova Scotia to Manitoba and south to the Gulf States (Georgia and South Carolina to Mississippi), *D. flagellare* has been collected only a few times west of the prairies, in Alberta (Slave Lake, Athabasca River, and Fort Saskatchewan) and British Columbia (Prince George and the Arrow Lakes). Its discovery as far north as the Liard Hotsprings is rather surprising.

Gymnostomum recurvirostrum Hedw. On tufa cliffs, both dry and wet portions, mostly heavily lime-encrusted, Nos. 22163, 22169, 22171; No. 22175 p.p., with *Riccardia pinguis*; No. 22184; near springs, No. 22183 p.p., with *Cratoneuron falcatum*; in a pool, No. 22164; beside a hot pool, No. 22055 p.p., with *Parnassia palustris* var. *neogaea*; in a marly bog, No. 22054 p.p., with *P. palustris* var. *neogaea*.

Tortella fragilis (Hook. & Wils.) Limpr. On tufa cliffs, No. 22162 p.p., with *Trentepohlia aurea*; Nos. 22175, 22177; in dry places on a tufa cliff, No. 22166.

Didymodon tophaceus (Brid.) Jur. On the bottom of a pool 2 feet deep, 66°F., heavily lime-encrusted, No. 22168. According to Grout's *Moss Flora*, this species grows "in calcareous habitats, on wet soil, moist hillsides and cliffs, and in springs and brooks, where it may be permanently inundated," from New York to British Columbia, southward to Mexico and Tennessee. It is particularly common in the American Southwest and in Mexico but apparently rare as far north as Canada. It has been found recently in the Gaspé peninsula of Quebec (Crum & Williams, 1960); other Canadian collections have been made at Owen Sound, Ontario; Peace River, Alberta; and Kamloops and Esquimalt, British Columbia. It is one of the most important of the tufa-forming mosses.

Pohlia nutans (Hedw.) Lindb. On a rotten log, No. 22155 p.p., with *Pleurozium schreberi*.

Leptobryum pyriforme (Hedw.) Schimp. Beside trail to spring, No. 21970 p.p., with *Carex aenea*.

Bryum pendulum (Hornsch.) Schimp. On tufa cliff, No. 22177 p.p., with *Tortella fragilis*.

Bryum pseudotriquetrum (Hedw.) Schwaegr. At edge of pools, No. 21953 p.p., with *Agrostis scabra*; No. 21969 p.p., with *Sphenopholis intermedia*; in a marly bog, No. 21978 p.p., with *Carex heleonastes*; on tufa cliffs, No. 22182; No. 22189 p.p., with *Philonotis fontana*; on tufa around a spring, No. 21962 p.p., with *Muhlenbergia racemosa*; on a hummock, No. 22150; in seepage, No. 22170.

Mnium affine Bland. On a rotten log in a spring pool, No. 22147D; on a tufa cliff, No. 22174; mud at the edge of a hot spring, No. 22043 p.p., with *Ranunculus sceleratus* ssp. *multifida*.

Mnium longirostrum Brid. On rotten wood, No. 22148; beside a brook in a rich forest, No. 22156.

Mnium punctatum Hedw. On a hummock in a shallow pool, marly bog, No. 22145 p.p., with *Preissia quadrata*.

Philonotis fontana (Hedw.) Brid. On a rotten log in a spring pool, No. 22147B; in seepage, No. 22161; on tufa cliff, No. 22189.

Orthotrichum elegans Hook. & Grev. On a rotten poplar log, No. 22154A. New to British Columbia but already known from a few localities in Alberta (Drumheller, Athabasca Plains, and Fort Saskatchewan); common in the northeastern United States and adjacent parts of Canada west to Minnesota and Manitoba. This so-called species is the eastern counterpart of *O. speciosum* Nees and is very poorly differentiated from it. Although there is usually little difficulty in distinguishing the two, occasional specimens of *O. elegans* from various parts of the East have unusually large gametophytes and rather large, strongly plicate capsules; they could be referred to *O. speciosum* with equal justice and, indeed, would be if they had been collected in the West. Some interdigitation of range occurs in northern Manitoba at least, and the few collections of typical *O. elegans* as far west as Alberta and

British Columbia clearly support the downgrading of this poorly marked species to a varietal level, as *O. speciosum* var. *elegans* (Hook. & Grev.) Warnst.

Orthotrichum obtusifolium Brid. On a rotten poplar log, No. 22154. According to Grout's *Moss Flora*, this species is found "in southern Canada, across the continent, north to Alaska, south to Maryland and Arizona." It is most common in the Northeast, however, and occurs as a disjunct in the American Southwest (in both New Mexico and Arizona). It is distinctly uncommon in the Canadian West but has been found in several localities in Alberta (Kananaskis, Jumping Pound Creek, Fort Saskatchewan, and Peace River near Dunvegan) and British Columbia (Silverton, McLeod's Lake, Shuswap Lake, and Sicamous). This collection and a recent one from the Yukon (near Haines Junction, W. B. Schofield, 1957) are significant range extensions and make Grout's report from Alaska seem plausible.

Cratoneuron falcatum (Brid.) Roth. On tufa cliffs, Nos. 22172, 22178, 22179; No. 22189 p.p., with *Philonotis fontana*; near springs, No. 22183; by a hot pool, No. 22055 p.p., with *Parnassia palustris* var. *neogaea*; in a wet place in rich woods, No. 22077 p.p., with *Viola nephrophylla*.

Cratoneuron filicinum (Hedw.) Roth. On a rotten log in a spring pool, No. 22147A.

Campylium chrysophyllum (Brid.) Bryhn. At the base of an *Erigeron* rooted in water up to 120°F., edge of a hot spring, No. 22135 p.p., with *E. philadelphicus*.

Campylium hispidulum var. *sommerfeltii* (Myr.) Lindb. At base of various flowering plants, near or at edges of hot springs, including the hottest of them, up to 110°F., No. 21953 p.p., with *Agrostis scabra*; No. 22144 p.p., with *Mimulus guttatus*; No. 22127 p.p., with *Lobelia kalmii*.

Campylium polygamum (BSG) Bryhn. On hummocks, No. 22150; in a calcareous fen, No. 22004 p.p., with *Tofieldia glutinosa*; on tufa beside a hot spring, No. 22126 p.p., with *Lobelia kalmii*.

Campylium stellatum (Hedw.) Lange & C. Jens. Beside a hot spring, No. 21954 p.p., with *Bromus ciliatus*; No. 22127 p.p., with *Lobelia kalmii*; on a hummock in a brook below the hot springs, submerged not long before, No. 22186; in an overflow swamp, No. 22025 p.p., with *Salix myrtillofolia*; No. 22050 p.p., with *Drosera anglica*; in a black spruce bog, No. 22102 p.p., with *Oxycoccus microcarpus*; on a hummock, wet, calcareous depression in a black spruce bog, No. 22016 p.p., with *Spiranthes romanzoffiana*; on a calcareous hummock, larch fen, No. 22106 p.p., with *Primula mistassinica*; on rotten wood, No. 22153 p.p., with *Amblystegium serpens*.

Leptodictyum trichopodium (Schultz) Warnst. On a rotten log in a spring pool, No. 22147C.

Leptodictyum trichopodium var. *kochii* (BSG) Broth. On rotten wood, No. 22158 p.p., with *Amblystegium juratzkanum*.

Amblystegium juratzkanum Schimp. On rotten wood, No. 22158; on tufa around springs, No. 22087 p.p., with *Muhlenbergia racemosa*; near hot springs, No. 22127 p.p., with *Lobelia kalmii*; in a calcareous fen, No. 22087 p.p., with *Epilobium glandulosum* var. *adenocaulon*.

Amblystegium serpens (Hedw.) BSG. On rotten wood, No. 22153.

Drepanocladus aduncus var. *polycarpus* fo. *capillifolius* (Warnst.) Mönk. On the wet, marly shore of a pond, spruce forest, No. 22292 p.p., with *Carex aquatilis*.

Drepanocladus sendtneri fo. *aristinnervis* Mönk. Growing with *Hippuris vulgaris* in a cool forest pond, No. 22298 p.p.

Drepanocladus uncinatus (Hedw.) Warnst. Beside a brook in a rich forest, No. 22148.

Drepanocladus vernicosus (Lindb.) Warnst. Submerged in a shallow pool, No. 22151; on tufa around springs and on a cliff, No. 21962 p.p., with *Muhlenbergia racemosa*; No. 22003 p.p., with *Tofieldia glutinosa*; No. 22142 p.p., with *Solidago lepida* var. *elongata*; in overflow swamp land, No. 22025 p.p., with *Salix myrtillifolia*; No. 22050 p.p., with *Drosera angelica*; in a spruce-larch fen, No. 22098 p.p., with *Pyrola asarifolia* var. *purpurea*; near the warmest spring, with a temperature of 110°F., No. 22114 p.p., with *Mimulus guttatus*.

Tomenthypnum nitens (Hedw.) Loeske. On hummocks in a shallow pool, marly bog, No. 22145 p.p., with *Preissia quadrata*; in a spruce bog, No. 22069 p.p., with *Rubus arcticus*; No. 22102 p.p., with *Oxycoccus microcarpus*, No. 22139 p.p., with *Senecio pauciflorus*.

Brachythecium acutum (Mitt.) Sull. On a tufa cliff, No. 22176.

Brachythecium rivulare BSG. In overflow area, No. 22048 p.p., with *Cardamine pensylvanica*.

Brachythecium rutabulum (Hedw.) BSG. On rotten wood, No. 22157.

Pleurozium schreberi (Brid.) Mitt. On rotten logs, Nos. 22152, 22155; on the ground in a rich forest, No. 22185; in a black spruce bog, No. 21938 p.p., with *Equisetum palustre*; No. 21940 p.p., with *E. scirpoides*; No. 21975 p.p., with *Carex disperma*.

Platygyrium repens (Brid.) BSG. On bark of a spruce tree, No. 22160. New to British Columbia. The range given in Grout's *Moss Flora* reads "Europe, and North America east of the Rocky Mountains." The species is common and widespread in North America east of the prairies, but the only specimens at the National Herbarium of Canada collected west of Manitoba are one from Saskatchewan (Deception Lake) and a few from Alberta (Lesser Slave Lake, Fort Saskatchewan, Peace River).

Pylaisia polyantha (Hedw.) BSG. On rotten wood, including a poplar log, No. 22154 p.p., with *Orthotrichum obtusifolium*; No. 22159.

Hypnum lindbergii Mitt. On rotten wood on a tufa cliff, No. 22173; in an overflow area below the springs, No. 21972 p.p., with *Carex capillaris* var. *elongata*; No. 22190; on tufa around springs and pools, No. 21962 p.p., with *Muhlenbergia racemosa*; No. 22132 p.p., with *Aster* sp.; edges of pools and hot springs, No. 21953 p.p., with *Agrostis scabra*; No. 21954 p.p., with *Bromus ciliatus*; No. 21969 p.p., with *Sphenopholis intermedia*; spruce bogs, No. 21957 p.p., with *Calamagrostis inexpansa*; No. 22069 p.p., with *Rubus arcticus*; No. 22093 p.p., with *Cornus canadensis*; in rich spruce woods, No. 22079 p.p., with *Viola nephrophylla*.

Ptilium crista-castrensis (Hedw.) DeNot. On rotten logs, No. 22155 p.p., with *Pleurozium schreberi*; No. 22180 p.p., with *Dicranum flagellare*.

Hylocomium splendens (Hedw.) BSG. On a log beside a brook, No. 22152 p.p., with *Pleurozium schreberi*.

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